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# The Cohoes Development

HYDRO-ELECTRIC PLANT CAPABLE OF DELIVERING 50,000 HP.; SINGLE MODERN STATION REPLACES NUMBER OF SCATTERED PLANTS EMPLOYING OBSOLETE EQUIPMENT

JUST PREVIOUS TO the year 1830, the Cohoes Co. was organized for the purpose of securing control of the water power rights in the vicinity of Cohoes Falls on the Mohawk River near its entrance to the Hudson.

Up to the present time, the extent of this company's holdings consisted of a dam and a canal system on various levels about 3 miles long. This system was and still is at the time of this writing used to supply water for driving numerous water-wheel driven industrial plants in and about the city of Cohoes, N. Y., the principal consumers of this power being many of the local mills. It is, however, stated that, as soon as the necessary changes can now be made, a number of these isolated water-wheel stations will be discontinued and the power furnished by them replaced by energy obtained from the Cohoes Co.'s new station.

A few hundred feet above the new power station is a natural fall in the Mohawk River, while approximately 5000 ft. beyond this is the company's old dam, a masonry structure 1400 ft. in length, with its crest at an elevation of 157.0 ft. above tidewater, and as the low water level at the power house is 58.0 ft., a fall or total head of 99.0 ft. is thus obtainable. It is from this point that the high-level canal extends to about 2000 ft. into the manufacturing district beyond the forebay of the new station.

FIG. 1. GENERAL VIEW OF COHOES HYDRO-ELECTRIC DEVELOPMENT

In Figs. 1 and 2 are shown a general plan and sectional views of this new plant. The gate house and power house buildings are of brick, concrete and steel construction, the latter consisting of a main operating room 40 by 165 ft., and 39 ft. high, divided into 10 equal bays, and a 2-story switch house, 25 by 165 ft., and 24.5 ft. in height.

An elevator and stairway leading to a connecting bridge provide a ready means of access from power house to gate house.

Ample illumination is obtained during the hours of daylight through large windows located in all 4 sides of the building, especially in the generator room, where large corrugated glass windows are installed on 3 sides. At night, illumination is produced by 400-watt gas-filled incandescent lamps provided with reflectors and mounted on brackets along the walls.

### Hydraulic Equipment

As shown in Fig. 2, head gates are provided at the entrance of the canal with a spillway just beyond for the purpose of controlling and regulating the level of the canal water.

From this point, the water flows down the canal until it reaches the forebay of the station, where it divides, part of it being carried to the mills, while the greater share passes through 3 20 by 22-ft. electrically operated penstock gates installed in the forebay gate house, which has provision for 5 gates. These gates are each operated by 25-hp. 220-v. induction motors which for normal operation are controlled in the gate house, although provision has been made so that, in case of an emergency, they may readily be operated from the main station switchboard.

Screens of 3½ by 5 1/16-in. rack bars, with 3-in. center spacings, and supported on an I beam, are placed in front of the gates, a traveling hoist being provided for handling the racks when necessary.

From the gate house, 3 penstocks 11 ft. in diameter, approximately 190 ft. long, and built up of steel plates ranging from ⅜ to ½ in. in thickness, drop directly to the wheels below. These penstocks are firmly anchored to concrete saddles, placed along the face of the bank and to the concrete substructure of the gate and power house.

The water wheel equipment consists of 3 10,000-hp. vertical, single-runner Francis type wheels, having a combined radial and axial flow and a single downward discharge into concrete draft tubes, and are placed so as to be 86 ft. below the level of the water in the forebay and 11 ft. below low water level. The general construction and comparative size of these wheels, which were built by the Platt Iron Works, of Dayton, O., is shown in Fig. 7.

When operating under a head of 96 ft., and full open gates, the normal rating of these wheels is 10,000 hp., while under an effective head of 90 ft. and full open gates, the rating is 8800 hp. Their normal speed is 185 r.p.m., and their maximum runaway speed is approximately 300 r.p.m.

Under the normal head of 96 ft., and while operating at a constant speed of 185 r.p.m., the guaranteed efficiencies of each wheel are as shown in the following table:

| | |
|---|---|
| 10,000 hp. | 85 per cent |
| 9,000 " | 87 " " |
| 8,000 " | 88 " " |
| 7,000 " | 86.5 " " |
| 6,000 " | 84 " " |
| 5,000 " | 80 " " |

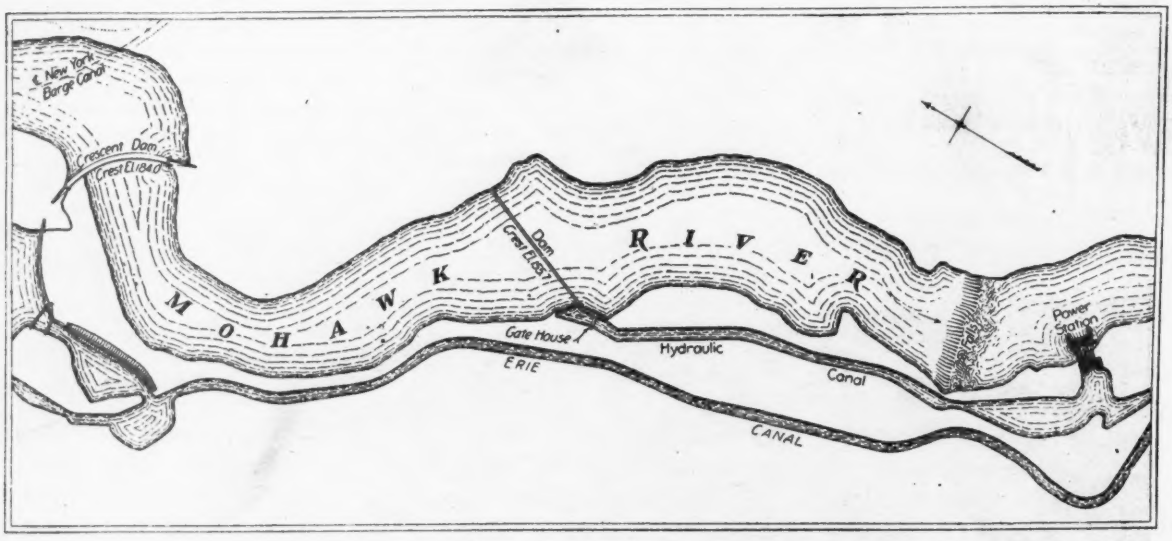


FIG. 2. MAP OF MOHAWK RIVER, CANAL AND POWER STATION

Each wheel is regulated by a 60,000-ft.-lb. Ontario type of Lombard governor, which is said to restore the speed of a unit within 0.5 per cent of normal from any change in load, and will begin to act before the speed has changed more than 0.5 per cent from normal, thus giving exceedingly close regulation.

The runners of these wheels are cast in one piece of a special mixture cast iron, and by means of specially treated cores and careful machining, smooth overall surface and accurate balance have been obtained.

The complete runner with shaft is steadied by 2 guide bearings, one of which was furnished with the generator, while the other, which is lined with lignum-vitae and lubricated with filtered water, was furnished by the turbine manufacturers.

### Generators

Although space has been provided for 5 generating sets, but 3 have so far been installed. These consist of the water wheels mentioned above, each driving a 9000-kv.a., 12,000-v., 40-cycle, 3-phase General Electric alternating-current generator at a normal speed of 185 r.p.m. The generators are equipped with Kingsbury bearings, to take the weight, which for the revolving member of each machine is approximately 50 tons.

rotor, thus allowing the connections to the brush holders to be made below the floor level and eliminating the necessity of carrying the field connections to the top of the machine outside of its frame or through a hollow shaft. Necessary inspections, cleaning and repairs of collector rings, brushes and brush holders can readily be made from the pit below the machine.

For the proper ventilation of the generators, special openings are provided to conduct the fresh air from the

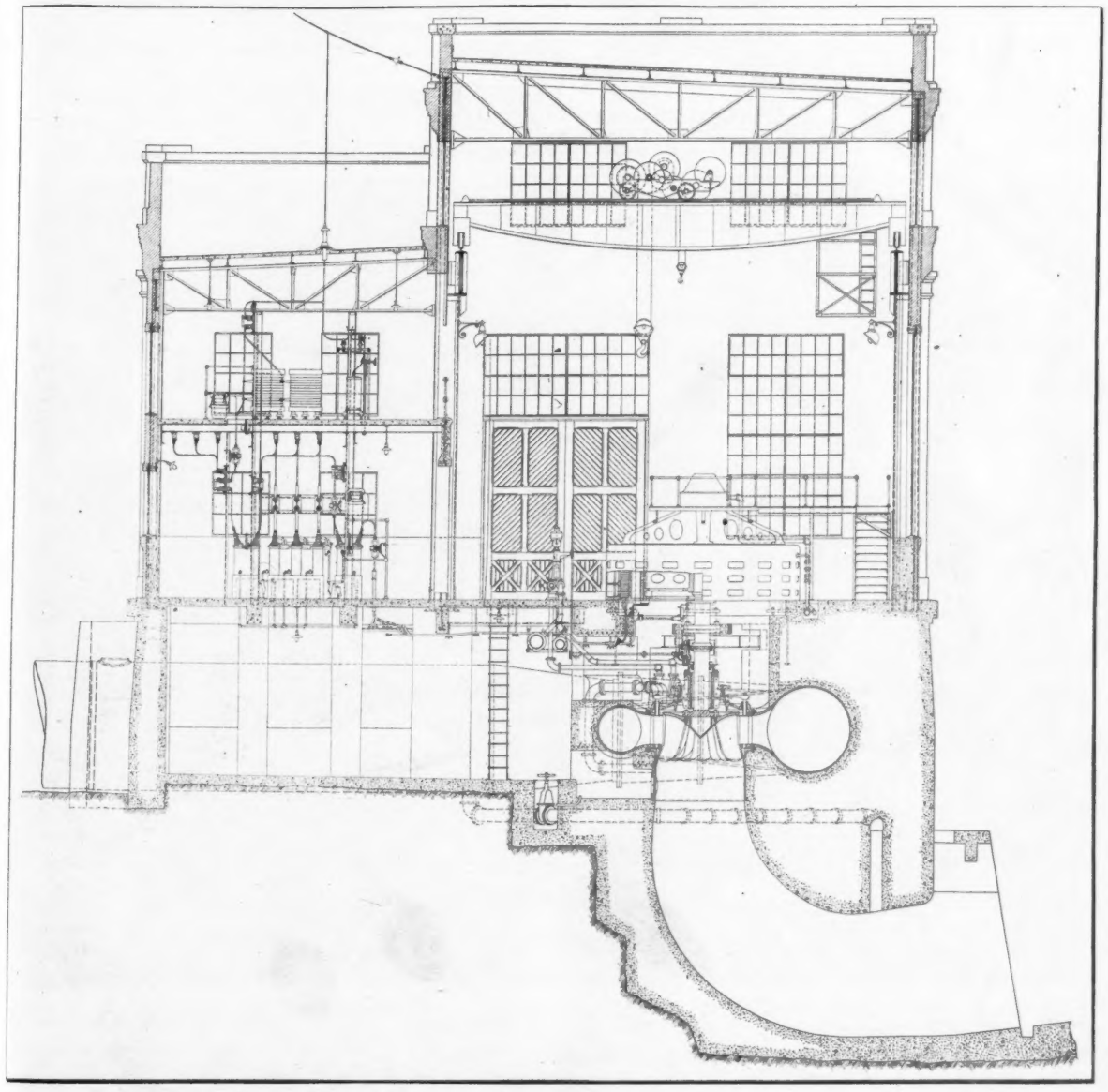

FIG. 3. CROSS SECTION OF POWER HOUSE

All armature windings are Y connected and are built up of form coils of the barrel type, all coils being interchangeable.

An interesting feature of these generators is the location of the collector rings. Instead of being placed above the rotor, as is usually done in the case of vertical type machines, the rings have been located below the

outside into the machine pit, whence it is drawn by the fanning action of the rotor throughout the windings and into the turbine room, and is allowed to escape through the natural openings of the building. By this method, fresh air is continually passed through the machine windings instead of reusing it as is generally done.

Oil for the generators is passed through filters located in the basement of the station, and then pumped to 2 storage tanks located near the roof of the turbine room. Flow indicators, thermometers, and oil meters are placed on the oil lines so that the attendant can positively tell whether the oil is flowing, the quantity flowing and its temperature.

Excitation for the generators is obtained from either one or both of 2 General Electric motor generator exciter sets, the motors of which are each of the squirrel-cage induction type, operating at 2300 v. and having a rating of 250 hp., while the generators are compound wound and rated at 165 kw. and 250 v.

For emergency station lighting, and oil switch and governor motor operation, a 125-v., 60-cell storage battery is installed, with a 3½-kw. motor-generator charging set which is operated continuously with the battery floating.

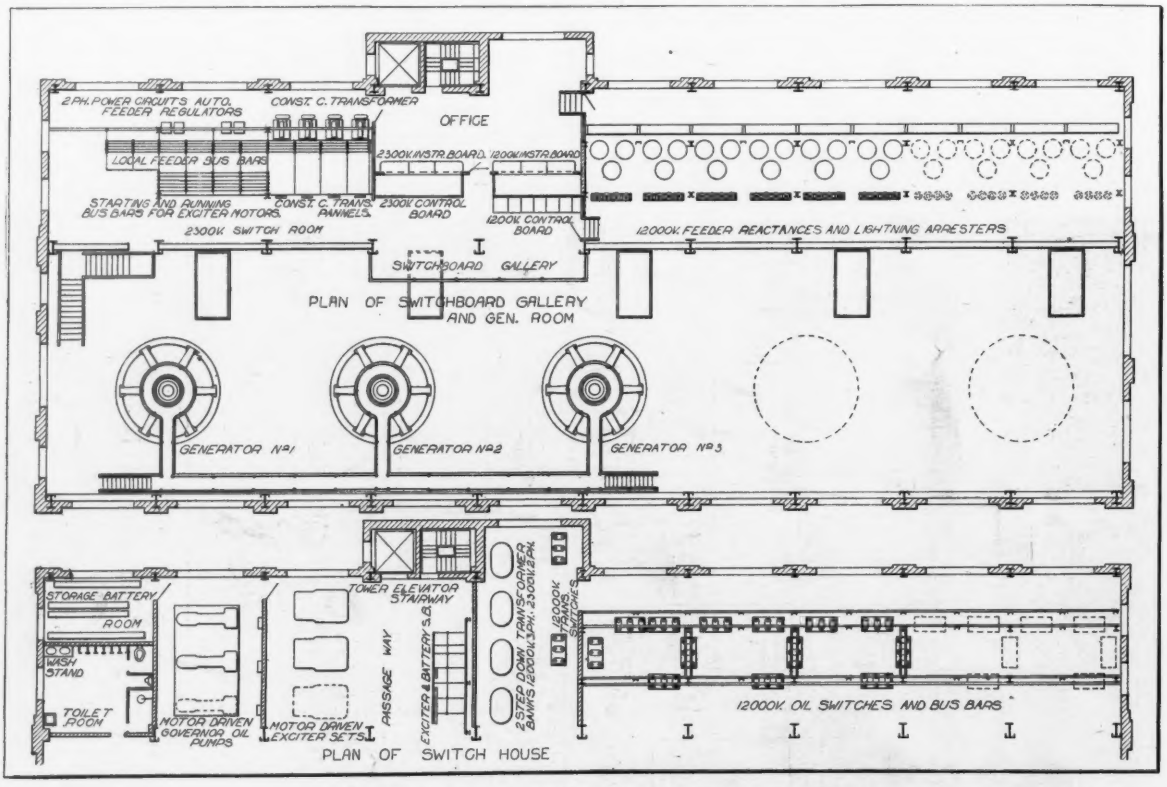
2 PH. POWER CIRCUIT'S AUTO. FEEDER REGULATORS
CONST. C. TRANSFORMER
OFFICE
LOCAL FEEDER BUS BARS
2300 K. INSTR. BOARD
1200 K. INSTR. BOARD
STARTING AND RUNNING BUS BARS FOR EXCITER MOTORS.
CONST. C. TRANS. PANELS.
2300 K. CONTROL BOARD
1200 K. CONTROL BOARD
2300 K. SWITCH ROOM
12000 K. FEEDER REACTANCES AND LIGHTNING ARRESTERS
SWITCHBOARD GALLERY
PLAN OF SWITCHBOARD GALLERY AND GEN. ROOM
GENERATOR No 1
GENERATOR No 2
GENERATOR No 3
STORAGE BATTERY ROOM
WASH STAND
TOILET ROOM
MOTOR DRIVEN GOVERNOR OIL PUMPS
MOTOR DRIVEN EXCITER SETS
TOWER ELEVATOR STAIRWAY
PASSAGE WAY
EXCITER & BATTERY S.B.
2 3 STEP DOWN TRANSFORMER BANKS 12000 K. 3 PH. 2300 K. 2 PH.
12000 K. TRANS. SWITCHES
12000 K. OIL SWITCHES AND BUS BARS
PLAN OF SWITCH HOUSE

FIG. 4. PLAN OF GENERATOR ROOM AND GALLERY SECTION

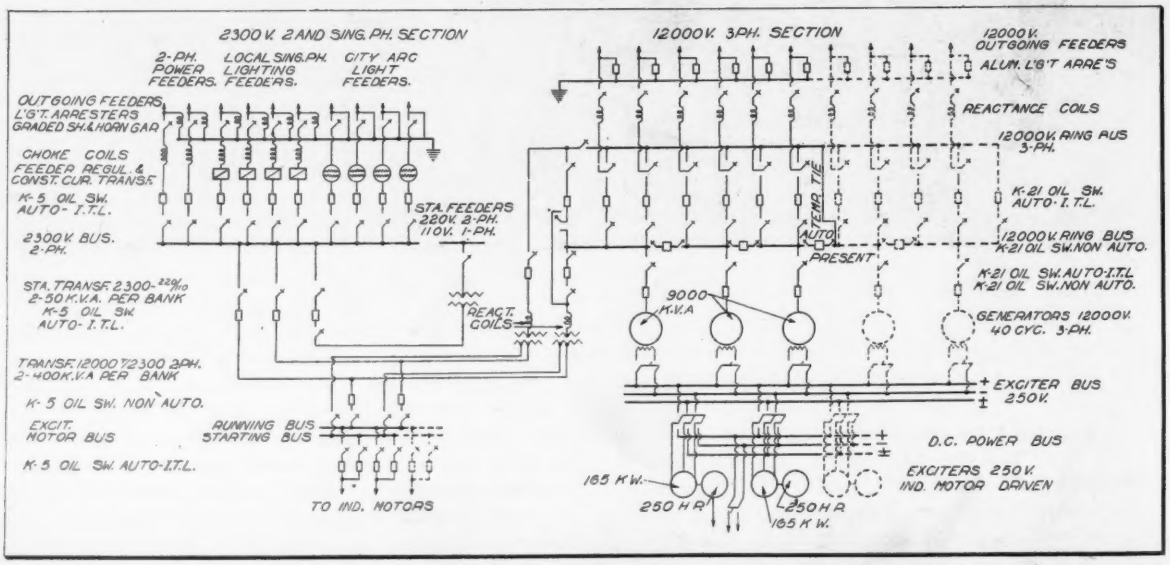
2300 V. 2 AND SING. PH. SECTION
12000 V. 3 PH. SECTION
12000 V. OUTGOING FEEDERS
ALUM. L'G'T ARRE'S
2-PH. POWER FEEDERS.
LOCAL SING. PH. LIGHTING FEEDERS.
CITY ARC LIGHT FEEDERS.
OUTGOING FEEDERS L'G'T. ARRESTERS GRADED SH. & HORN GAP
REACTANCE COILS
12000 V. RING BUS 3-PH.
CHOKE COILS FEEDER REGUL. & CONST. CUR. TRANSF.
K-5 OIL SW. AUTO-I.T.L.
K-21 OIL SW. AUTO-I.T.L.
STA. FEEDERS 220 V. 2-PH. 110 V. 1-PH.
2300 V. BUS. 2-PH.
TEMP. TIE
AUTO
PRESENT
12000 V. RING BUS K-21 OIL SW. NON AUTO.
K-21 OIL SW. AUTO-I.T.L
K-21 OIL SW. NON AUTO.
STA. TRANSF. 2300-220/110 2-50 K.V.A. PER BANK K-5 OIL SW. AUTO-I.T.L.
REACT. COILS
9000 K.V.A
GENERATORS 12000 V. 40 CYC. 3-PH.
EXCITER BUS 250 V.
TRANSF. 12000/2300 3PH. 2-400 K.V.A PER BANK
K-5 OIL SW. NON AUTO.
EXCIT. MOTOR BUS
RUNNING BUS
STARTING BUS
D.C. POWER BUS
K-5 OIL SW. AUTO-I.T.L.
EXCITERS 250 V. IND. MOTOR DRIVEN
165 K.W.
250 H.P.
250 H.P.
165 K.W.
TO IND. MOTORS

FIG. 6. DIAGRAMMATIC SCHEME OF STATION CONNECTIONS

### Transformers and Lightning Arresters

As the generator voltage is the same as the high-tension transmission voltage, no step-up transformers are employed in this station. For the local electric light and power supply, 4 400-kv.a. oil insulated and self-cooled transformers connected up in banks of 2 and transforming from 12,000 v., 3-phase to 2300 v., 2-phase are used, T connected on the primary side and 4-wire on the secondary side.

Each of the transformer units is controlled on its primary side by a 3-phase, 12,000-v., oil switch, electrically operated from the main switchboard, mounted in a concrete base 24 in. high and inclosed by a screened protective railing.

Each primary leg of these transformers, as well as each outgoing high tension feeder, is provided with porcelain clad reactance coils, such as shown in Fig. 10.

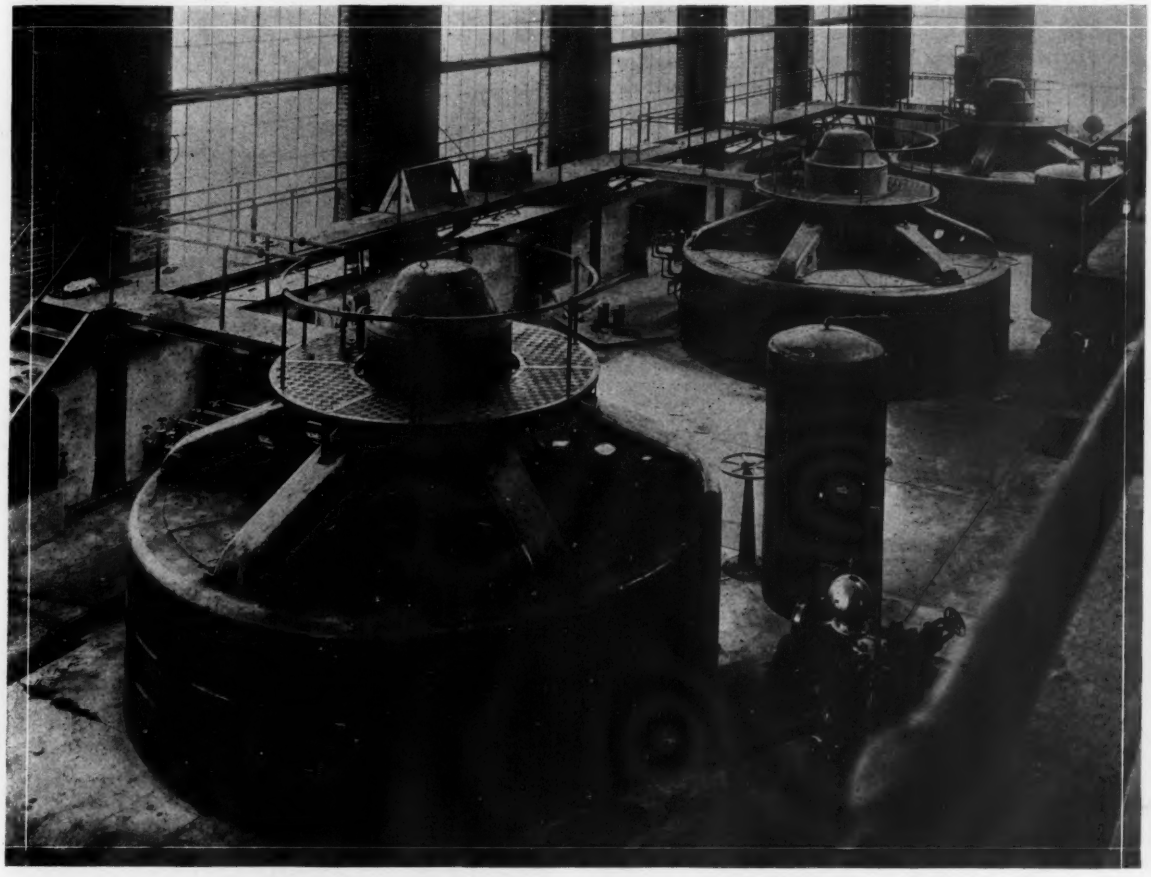

FIG. 5. INTERIOR OF GENERATOR ROOM SHOWING 3 9000-KV.A. GENERATORS

On the 12,000-v. feeders, triple-pole aluminum-cell lightning arresters are used, while on the 2300-v. distribution and arc lighting circuits, double-pole multi-graded shunt arresters and double-pole horn-gap arresters respectively are installed.

### Auxiliary Station Equipment

Two 50-kv.a. single-phase transformers connected to the 2300-v., 2-phase bus bars and delivering 220 and 110 v. on the secondary side, are used for the station light and power service, all motors being of the 220-v., 2-phase type.

For the supply of compressed air, a motor-driven air compressor and supply tanks is installed, while the station heating is obtained from a small exterior low-pressure steam heating plant.

For local street lighting, 75-light, 2300-v., 6.6-amp., constant-current transformers are installed, the 2300-v. local feeders being provided with single-phase, induction type automatic feeder regulators complete with limit switches, contact-making voltmeters and line drop compensators. These regulators are designed to give a buck or boost of about 5 per cent.

### Switchboards and Bus Compartments

In Fig. 8 is shown the exciter board, while Fig. 9 illustrates the 4 arc-lighting panels, the 2300-v. control switchboard and the bench board in the order named. All of these boards are made of black slate, except the arc light panels, which are of blue Vermont marble.

The exciter board, which is located in the main floor of the station near the motor generator exciter sets, is built up of 6 panels upon which are mounted the exciter control switches, instruments and rheostats, the solenoid-operated, motor-controlled generator field switches, the low-voltage station light and power feeder switches, and the storage battery control. All other switchboards are on the gallery.

The 2300-v., 2-phase switchboard is used for the control of the low-tension side of the 400-kw. transformers and their outgoing circuits, and is built up of 7 panels with corresponding rear panels. Upon the front panel of this board are mounted the indicating meters, a General Electric voltage regulator, and a dummy bus showing a one line diagram of the 2300-v. equipment. Upon the rear of this are the recording watthour meters, relays, testing terminals and a testing meter bench provided for the purpose of testing meters.

All oil switches controlling the 2300-v. lines are electrically operated from this board by voltage control.

Most important of all the switchboards is the bench board, which is employed for the control of the generators, exciters and 12,000-v. bus bars and feeders, and as shown in Fig. 9, is located just beyond the

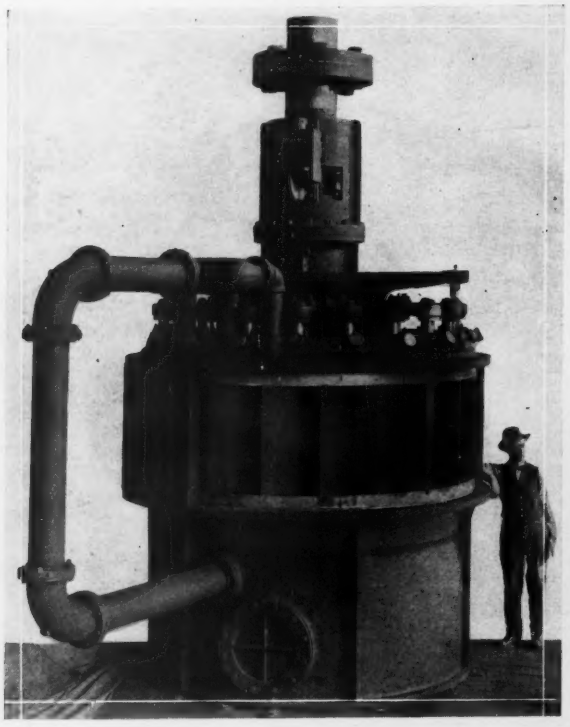

FIG. 7. 10,000-HP. FRANCIS TYPE OF WATER WHEEL USED

2300-v. board. This board consists of 7 panels, each with a vertical panel back of it, the whole enclosed by iron screening. The upper vertical section of the bench board contains the indicating voltmeter, ammeters, wattmeters, power factor indicator, speed indicator and field ammeter for each generator and the exciter ammeters and common voltmeter. On the bench section is found a dummy bus as on the 2300-v. switchboard, which shows in detail a complete single line diagram of the main station equipment, the control switches for remotely operated oil switches and synchronizing receptacles. On the lower vertical section are the control switches for the remote-controlled rheostats and governors, the exciter and equalizer handwheels and the station bell alarm relay. These panels in the rear of the bench board have mounted upon them the curve drawing and recording meters, relays, testing terminals and meter testing bench as mentioned in the description of the 2300-v. switchboard. This board has also mounted upon it the governor speed and head-gate control switches.

In Fig. 6 is illustrated a single line diagram of the station connections, an interesting feature of which is the ring bus, obtained by running an additional set of

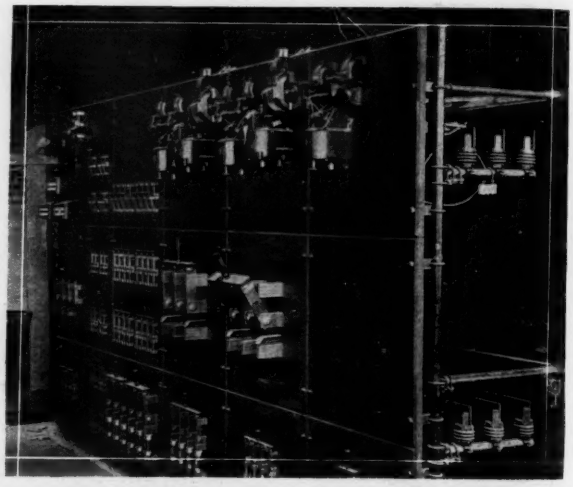

FIG. 8. EXCITER SWITCHBOARD

bus bars parallel to the regular bus, and connected to the first and last bus section switches. Should any feeder switch become temporarily disabled for any reason, service interruption need not result, as the feeder in question can readily be thrown on this extra set of

FIG. 9. BENCHBOARD AND 2300-V. CONTROL SWITCHBOARD

bus bars by means of a double throw disconnecting switch, and may be controlled by the last bus section switch.

As may be seen in Fig. 6, the electrical connections consist of 2 distinct parts, one which embodies all of the high-tension 3-phase bus and switching equipment, and the other for 2300-v. single and 2-phase transformers, bus bars and other apparatus.

DISTRIBUTION

ALTHOUGH provision has been made for 10, there are at present but 6 outgoing, 12,000-v., 3-phase circuits, which leave the station through roof entrance bushings in the roof of the gallery. Of the 2300-v. service cir-

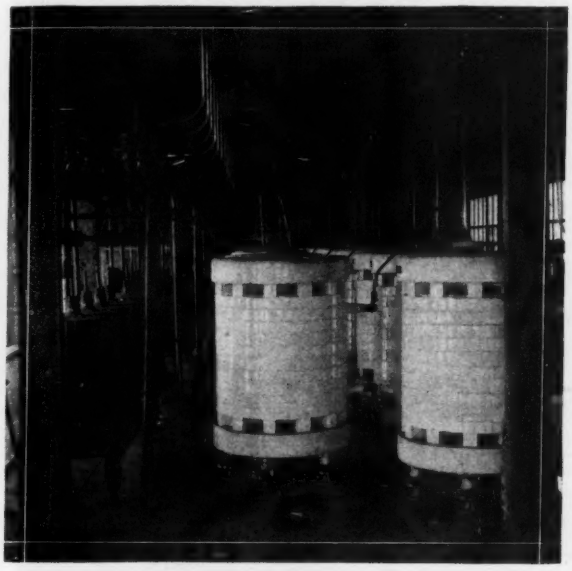

FIG. 10. FEEDER REACTORS AND LIGHTNING ARRESTERS

cuits, there are 2 2-phase 4-wire motor circuits, 4 single-phase house lighting circuits and 2 street lighting circuits, all of which leave the building through wall entrance bushings. All of these lines, both high and low tension, run to steel towers mounted on extensions of the

FIG. 11. VIEW OF LOW-TENSION SWITCHING APPARATUS AT COHOES

concrete foundations of the gate house, the 12,000-v. lines being above, with the 2300-v. lines directly below.

The engineering work on this project was done by Sanderson & Porter, of New York City, while most of the electrical equipment has been furnished by the General Electric Co.

# News from Washington

BY A. P. CONNOR

IT is unofficially reported that the fuel tests of the torpedo boat destroyer Wadsworth, now on trial in Maine waters, have shown remarkable results. It is even claimed that the economy of fuel exhibited at all speeds has never been shown on any other steam vessel of any description in the world. This vessel has been developed under new designs by the U. S. Navy Department, and it has the special feature of being gear driven. She is expected to be delivered over to the Government during the month of July. The official results of the tests will not be available for some weeks.

It is said that Germany has sent submarine from Wilhelmshaven in German territory to the Dardanelles, a distance of about 5000 miles. When it is realized that the United States is only about 3600 miles from the same place, a much better idea of the feat can be appreciated. From a power point of view in connection with the conditions that exist on a submarine, the feat is especially remarkable. From an engineering outlook, it speaks well for the technical skill responsible for the design and operation of these modern sea-craft.

The approximate horsepower of the large guns that have been hurling shells at Dunkirk from a point about 23 miles away, is said to be 800,000 hp., while it lasts. The length of time it lasts is about one-onethousandth part of a second. Considering the amount of space they take up, these guns are the most efficient engines in existence.

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AFTER BEING summoned to a plant where trouble was reported, the inspector found, on visiting the plant, that water had been carried over copiously to the engine cylinder ever since a certain boiler had been placed back in service, following repairs. The walls and floor of the engine room gave abundant evidence of the faithful service which the relief valves had been called on to perform.

Finding that no previous trouble had been experienced from foaming or priming, he proceeded to examine the boiler which had just been put back in service. The trouble was not hard to explain when he entered the steam space. The boiler was of the horizontal return tubular type, and he found that recent changes had been made in the internal feed pipe, following a request at a previous inspection that the pipe be more securely fastened to the braces. A steam fitter had been assigned to this job who, it seems, thought he could more firmly attach the pipe by dispensing with that portion which extended across the boiler near the back end. He disconnected this cross pipe, but decided to leave the elbow attached to the longer portion which ran back parallel with the tubes from the front head. In his efforts to make as secure and strong a job as possible, he raised the rear end of the pipe up among the braces, where he lashed it fast in such a position that the upturned elbow on its end reposed near and almost in line with the nozzle from which steam was drawn. It is easy to see that the feed water must have been discharged into the steam space in such a way that it was practically forced as a jet, to pass out along with the steam.—The Locomotive.

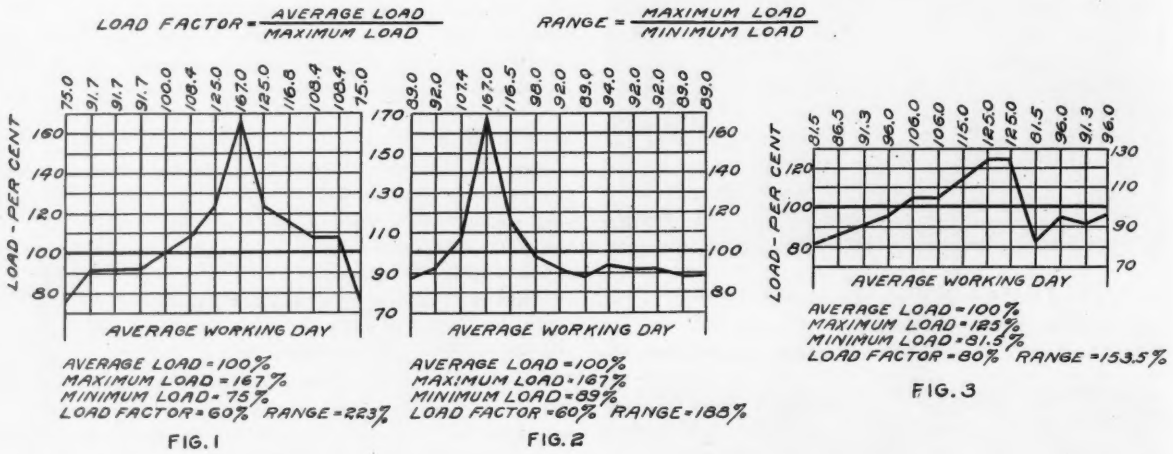
# Apportioning the Load to the Power Equipment

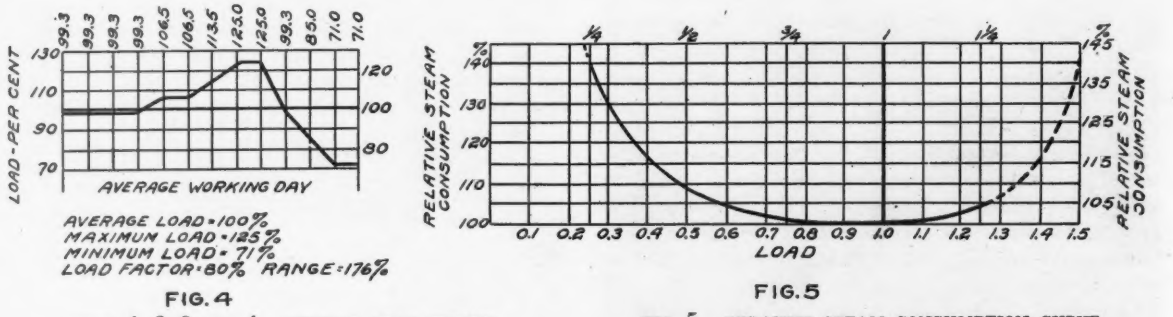
ANALYSIS OF CONDITIONS GOVERNING THE ECONOMIC APPORTIONING OF LOAD; PROPER METHOD TO BE EMPLOYED IN SELECTION OF EQUIPMENT. BY REGINALD TRAUTSCHOLD

IF it were possible to maintain a constant load for a steam power house, it would be a simple proposition to select the most economical power unit or units and to operate the plant at maximum efficiency and least cost. The power units could be run under full load at all times, at which rating they are most economical in the consumption of steam—but unfortunately, this is rarely, if ever, possible. There is nearly sure to be some variation in power requirements of even the most efficiently operated plants, as far as constancy of load is concerned, and the variations in the large public-service plants are particularly trying. In fact, it is this question of variability of load in the central station that frequently makes it impossible for such a plant to compete with a much smaller isolated plant, operating under fairly constant power demands, although the larger plant may be favored with more efficient equipment and ability to purchase supplies at considerably more advantageous prices.

Classification of power plants according to load requirements is commonly arrived at by designating the load factor of the plant, that is, the ratio of the average load during a certain period to the maximum load carried within that period. The duration of the maximum loads, the peaks, should advisably also be stated. From such data, when actually known, which is seldom, the power generators of the plant have to be selected and the load so apportioned to the engines as to permit the most economic and efficient operation of the plant. Naturally, with no more specific data to work on than the probable load factor of the plant, even with the valuable extra knowledge of duration of peaks, there is always considerable leeway for error in selecting the most economical power equipment. It will be the object of this discussion, therefore, to analyze the conditions governing the economic apportioning of the load to the engine and to present a few simple rules whereby greater accuracy in choosing the most economical power equipment can more easily be arrived at than when selecting the engines in the ordinary way, that is, selecting the main equipment to care for the average load and depending upon auxiliary equipment to carry the peaks.

In order that the discussion may be general and the rules advanced applicable to the average plant, data will be presented as far as possible in percentages. Plants subject to a low load factor obviously necessitating considerable complexity of equipment and plants operating under exceptionally high load factors presenting no great difficulties for economic selection of equipment, the discussion will be further limited to con-


LOAD FACTOR = AVERAGE LOAD / MAXIMUM LOAD
RANGE = MAXIMUM LOAD / MINIMUM LOAD
LOAD - PER CENT
AVERAGE WORKING DAY
AVERAGE LOAD = 100%
MAXIMUM LOAD = 167%
MINIMUM LOAD = 75%
LOAD FACTOR = 60% RANGE = 223%
FIG. 1
AVERAGE LOAD = 100%
MAXIMUM LOAD = 167%
MINIMUM LOAD = 89%
LOAD FACTOR = 60% RANGE = 188%
FIG. 2
AVERAGE LOAD = 100%
MAXIMUM LOAD = 125%
MINIMUM LOAD = 81.5%
LOAD FACTOR = 80% RANGE = 153.5%
FIG. 3




FIGS. 1, 2, 3 AND 4. TYPICAL LOAD CURVES

FIG. 5. RELATIVE STEAM CONSUMPTION CURVE

sideration of only plants with fairly high load factors and those which the load factor is not extremely low—fairly typical exacting conditions alone will be taken up.

Figures 1, 2, 3, and 4 graphically show fluctuations of load in typical plants, the first 2 having a load factor of 60 per cent and the other 2, 80 per cent. Figure 5 shows the relative steam consumption of the average highgrade reciprocating engine operating under various degrees of load. The records depicted by this latter curve apply equally as well to condensing as to non-condensing engines and operation on saturated steam of any ordinary pressure and on superheated steam. The quality of the steam and whether the engine is run condensing or otherwise affects the economy of steam consumption, it is true, but the relative economy in steam consumption for a given degree of load is nearly the same in all cases. The data depicted in Fig. 5 may then be taken as typical of any reciprocating engine of ordinary construction, irrespective of type of engine or quality of steam employed. When extreme accuracy is required, a load characteristic curve of the particular type of engines under consideration should be used instead of the curve of Fig. 5, but for all practical purposes this curve proves satisfactory.

The actual load curves of the respective plants would, of course, show considerably more unevenness, minor fluctuations being quite apparent, than the smooth curves of Figs. 1, 2, 3, and 4, but again, for all practical purposes, no more accurate records are necessary. It will be noted that the data accompanying the load curves contains the minimum working load as well as the maximum load that is necessary for ascertaining the load factor of the plant. It is just as important economically to handle the minimum working load as the maximum load, a fact that is often overlooked when depending only upon the load factor and maximum load for the selection of power equipment. The range of load obtained in per cent by multiplying the quotient of the per cent of minimum load divided by per cent of minimum load by 100, is just as important as the load factor when it comes to true economy in the choice of equipment.

Rarely is it deemed advisable to load an engine more than 25 per cent over its full load rating on account of the rapidly diminishing economy in steam consumption of an engine under heavier load; but, on the other hand, engines are frequently called upon to carry but 25 per cent of the load they carry with minimum relative steam consumption, that is, at full load. Actually, the average engine could be operated just about as efficiently, as far as steam consumption is concerned, at 50 per cent overload as at 25 per cent of load, see Fig. 5. If, then, ¼ load be the minimum, it is advisable, from the point of view of economy, for an engine to carry, 1½ load should represent the maximum load limit. With such limits, the economical range of the average engine would be 600 per cent, a range that could not under any circumstances permit the realization of an economical average rate of steam consumption unless both periods of maximum and minimum load were of very short duration. In other words, the economically selected engine would never be subjected to the uneconomic practice of working under ¼ load. If ¼ overload be taken as the maximum load an engine of ordinary construction can economically carry, the minimum load should be somewhat over ½ the rated capacity of the engine at full load—such limits about equalizing the inefficiencies at over and under load.

For convenience in analyzing the typical engine load curve, the lower portion of the curve in Fig 5 is reproduced at a much larger and considerably distorted scale on Chart I of the Reference Tables. The lines connecting points on the load curve indicate the minimum and maximum degrees of load for a well balanced engine to carry in order to cover the load range specified for the various connecting lines. These lines are parallel, connect points on the load curve of equal economy in steam consumption until the maximum load becomes 25 per cent over the full load rating of the engine after which the maximum load is not increased, but the greater range secured by simply reducing the minimum load. So balancing the power range or load range of the engine, limits the economical range to one of about 250 per cent, beyond which it would be advisable to carry the peak load on auxiliary power units, thereby allowing an increase in the relative minimum load carried by the main equipment and a corresponding reduction in the size of the units required.

Obviously, for any well balanced load range, the economical rating of the power equipment at average load would only be the same as at full load when there was no variation in load, that is, only when the load range equaled 100 per cent. At any other load range, the rating would depend upon the load factor and for each load range, when well balanced, there would be a co-efficient by which the load factor should be multiplied to ascertain the economical power rating of the equipment at average load. Such co-efficient could be directly ascertained from Chart I, but is much more easily picked out from a chart on which the load range is laid out on a simple scale—see Chart II. This latter chart is based on the assumption that the maximum load any engine can economically carry is limited to one 25 per cent greater than the engine's full load rating. A simple illustration will best serve to explain the convenience of this chart.

It will be assumed that an engine is to be subject to a load range of 200 per cent and a load factor of 60 per cent. From Chart II the load factor co-efficient for a range of 200 per cent is seen to be 1.23. The economical power rating of the engine at average load, provided the load is well balanced, would then be 1.23 times 0.60 or 0.738—that is, the average load should be carried by the engine when it is operating at 73.8 per cent of its capacity at full load. Of course, if the load is not well balanced and the peak unusually severe or the minimum working load exceptionally light, the economical engine rating at average load would be either slightly less or slightly more, respectively, than 73.8 per cent of the average load. Usually, however, the fluctuations of load would not require such modification unless the range was so extreme as to make it advisable to carry the peaks on auxiliary equipment.

Referring again to the typical load curves, an inspection of Fig. 1 clearly shows that equipment proportioned to carry the average load at full load rating of equipment could not handle the peak without seriously overloading the engines. More powerful equipment

would be required unless auxiliary equipment is installed for carrying the peak load. The plant being subject to a load range of 223 per cent, complicating the plant by the installation of auxiliary equipment would not seem advisable. At least, a simple plant without auxiliary equipment will first be considered and later the advisability of complicating it may be taken up. Chart II shows the advisable load factor coefficient to be 1.25, if special equipment for handling the peak is not installed, and, the load factor being 60 per cent, the economical power rating of the equipment at average load would be 1.25 times 60 or 75 per cent. That is, the smallest power unit, considering the power equipment of the plant as one unit, would be that which handled the average load when carrying ¾ of its full load capacity, or had a full rating 1⅓ the plant average load. Subsequent analysis will show that the steam consumption of the plant is at a minimum with such proportioned equipment.

FIG. 6. PROBLEMS A AND B

Percent Rating at Various Loads = Plant Loads from Load Curve Readings times ratio of average load to rated capacity.

Relative Steam Consumption = Readings from Chart I corresponding to Power Rating at Various Loads times number of similar Load Curve Records.

Example A.

Conditions: - Data same as that for Fig. 1, Power Equipment Rating at average load, 75 per cent.

| Percent Rating at Various Loads | Relative Steam Consumption |
|---|---|
| 0.750 x 75 = 56.25 per cent | 106.05 x 2 = 212.10 |
| .917 = 68.78 | 102.45 x 3 = 307.35 |
| 1.000 = 75.00 | 101.50 x 1 = 101.50 |
| 1.084 = 81.30 | 100.87 x 3 = 302.61 |
| 1.168 = 87.60 | 100.40 x 1 = 100.40 |
| 1.250 = 93.75 | 100.13 x 2 = 200.26 |
| 1.667 = 125.00 | 105.00 x 1 = 105.00 |

Average Relative Steam Consumption ----------103.25 per cent.

Example B.

Conditions: - Data same as that for Fig. 2, Power Equipment Rating at average load, 70 per cent.

| Percent Rating at Various Loads | Relative Steam Consumption |
|---|---|
| 0.890 x 70 = 62.30 per cent | 104.02 x 4 = 416.08 |
| .920 = 64.40 | 103.40 x 4 = 413.60 |
| .940 = 65.80 | 103.05 x 1 = 103.05 |
| .980 = 68.60 | 102.50 x 1 = 102.50 |
| 1.074 = 75.18 | 101.47 x 1 = 101.47 |
| 1.165 = 81.55 | 100.85 x 1 = 100.85 |
| 1.667 = 125.00 | 105.00 x 1 = 105.00 |

Average Relative Steam Consumption ----------103.27 per cent.

Similar analyses of the plants represented by Figs. 2, 3, and 4, place the economic apportioning of the respective average plant loads at the following power equipment ratings: Fig. 2, 1.205 times 60 or 72.30 per cent; Fig. 3, 1.136 times 80 or 90.88 per cent; and Fig. 4, 1.184 times 80 or 94.72 per cent. These power equipment ratings may be taken, for practical purposes, as 70 per cent, 90 per cent and 95 per cent, respectively.

Having ascertained the economical power rating of equipment at the average load for the respective plants, according to the chart method, the deductions may be checked and the economies gained, if any, computed. These calculations are given in the following examples, the data governing the conditions of which are the same as those given in Figs. 1, 2, 3, and 4 for the respective plants, supplemented by that secured from Chart II. In all calculations, the relative steam consumption at full load rating of power equipment is taken as 100 per cent—the measure of maximum efficiency, unattainable with a varying plant load but which represents the record to be striven for. Example A gives the average relative steam consumption of the plant represented by Fig. 1 with a power equipment rated at 75 per cent of average load.

Let us follow the work of this problem in detail. Referring to Fig. 1, we find that at the beginning of the curve we have a 75 per cent plant load which value when multiplied by the ratio of average load to rated capacity, in this instance 0.75, is equal to 56.25, or the per cent rating at which the equipment is operating at 75 per cent plant load. Turning to Chart I, we find that with a 56.25 per cent load on the equipment, the relative steam consumption is 106.05. In a similar manner, the relative steam consumption at other points in the load curve is obtained. Due, however, to the fact that

FIG. 7. PROBLEMS C, D AND X

Example C.

Conditions: - Data same as that for Fig. 3, Power Equipment Rating at average load, 90 per cent.

| Percent Rating at Various Loads | Relative Steam Consumption |
|---|---|
| 0.815 x 90 = 73.35 per cent | 101.70 x 2 = 203.40 |
| .865 = 77.85 | 101.20 x 1 = 101.20 |
| .913 = 82.17 | 100.78 x 2 = 201.56 |
| .960 = 86.40 | 100.48 x 3 = 301.44 |
| 1.060 = 95.40 | 100.07 x 2 = 200.14 |
| 1.150 = 103.50 | 100.10 x 1 = 100.10 |
| 1.250 = 112.50 | 101.21 x 2 = 202.42 |

Average Relative Steam Consumption ----------100.79 per cent.

Example D.

Conditions: - Data same as that for Fig. 4, Power Equipment Rating at average load, 95 per cent.

| Percent Rating at Various Loads | Relative Steam Consumption |
|---|---|
| 0.710 x 95 = 67.45 per cent | 102.72 x 2 = 205.44 |
| .850 = 80.75 | 100.92 x 1 = 100.92 |
| .993 = 94.34 | 100.10 x 5 = 500.50 |
| 1.065 = 101.18 | 100.02 x 2 = 200.04 |
| 1.135 = 107.83 | 100.50 x 1 = 100.50 |
| 1.250 = 118.75 | 102.70 x 2 = 205.40 |

Average Relative Steam Consumption ----------101.06 per cent.

Example X.

Conditions: - Data same as that for Fig. 1, Power Equipment Rating at average load, 70 per cent.

| Percent Rating at Various Loads | Relative Steam Consumption |
|---|---|
| 0.750 x 70 = 52.50 per cent | 107.95 x 2 = 215.90 |
| .917 = 64.19 | 103.47 x 3 = 310.41 |
| 1.000 = 70.00 | 102.23 x 1 = 102.23 |
| 1.084 = 75.88 | 101.41 x 3 = 304.23 |
| 1.168 = 81.76 | 100.83 x 1 = 100.83 |
| 1.250 = 87.50 | 100.40 x 2 = 200.80 |
| 1.667 = 116.69 | 102.13 x 1 = 102.13 |

Average Relative Steam Consumption ----------102.81 per cent.

we have in Fig. 1, 2 75 per cent load points, 3 91.7 load points, 1 100 per cent load point, etc., it is necessary to multiply the respective values of the relative steam consumption by the number of times the like values of per cent load appear on the curve, as example, where the per cent load is 75, the relative steam consumption is multiplied by 2. The various values are then added and the total divided by the number of readings on the curve, thus giving an average relative steam consumption of 102.25 per cent.

It may be well at this point to note that, as the ratio of average load to rated capacity is 0.75, the ratio of rated capacity to average load is 1.333, so that instead of multiplying the per cent ratings at various load by 0.75, they may be divided by 1.333 and the same results obtained.

Examples B, C, D. X and E are worked in a like fashion. In example B we have similar information represented in Fig. 2 with power equipment rated at 70 per cent of average load.

Examples C and D, corresponding results for the plants represented by Figs. 3 and 4, with power equipment ratings at average load of 90 and 95 per cent respectively; Example X, the average steam consumption of the plant represented by Fig. 1, but with a power equipment rating at average load similar to that for the plant represented by Fig. 2, namely, 70 per cent of full load rating of equipment.

Although the plant represented by the load curve given as Fig. 1 is subject to a variation in load of 223 per cent, the average relative steam consumption is but 2.25 per cent greater than would be that of a similar plant operating under a constant load—see Example A. The average relative steam consumption of the other plant with a 60 per cent load factor furnished with equipment proportioned to carry the average plant load at 70 per cent of the power equipment rating is somewhat higher, although the load range is considerably less. This is due to the somewhat less efficient apportioning of the load to the power equipment—a slight decrease in the capacity of power equipment probably producing slightly better results as the advisable power equipment rating at average load is really 72.3 per cent instead of 70 per cent—and to the fact that the load cannot be as well balanced as in the case of the plant with a 223 per cent load range. For practical purposes, power equipment capable of handling the average load of the plant at either 70 per cent or 75 per cent of the power equipment rating would prove about equally economical—preference being given to the 70 per cent equipment rating, owing to the slightly greater load that could be carried in an emergency without overloading the equipment.

Examples C and D show results more usually encountered, increases in average steam consumption for increases in load range though the load factor may not vary. The value of the charts as aid in selecting properly proportioned power equipment is perhaps more apparent when consideration is taken of a plant such as that in Example A furnished with power equipment proportioned to carry the average load at 70 per cent rating of equipment, as in the case of Example B—see Example X. Such proportioning of power equipment shows some increase in average relative steam consumption; slight, it is true, but nevertheless appreciable when it is remembered that the equipment was proportioned in one case to carry the average load at 70 per cent of its full load rating, which is somewhat under economic rating, and in the other, 75 per cent.

Referring once more to Fig. 1 and to Example A, the conditions governing such plants, a load range of 223 per cent, might be deemed sufficient to install auxiliary equipment to carry the peak and to depend upon the main power equipment to care for the average load and such overload as the main equipment is capable of handling without undue overloading. That is, proportion the main power equipment to handle the average load of the plant when earrying full load and also depend upon the main units to carry the plant load up to 25 per cent over average load, the auxiliary equipment being employed only for the plant load of from 125 to 167 per cent of the average load, the main peak, at from 50 per cent to 125 per cent of the full load rating of the auxiliary equipment. The average relative steam consumption of the main equipment is naturally considerably better than when no auxiliary power equipment is employed—see Example E—the load factor being considerably increased. The capacity of the main power units need also be 25 per cent less if the peak is carried by auxiliary engines. It is doubtful, however, whether the actual steam consumption would be as economical for the smaller power units as for the larger ones. Assuming that the steam economy is the same for the smaller main power units and also for the auxiliary equipment—assumptions that would unfairly favor the more complicated plant—the steam consumption by the auxiliary engines when handling the peak loads must be taken into consideration to arrive at the plant's average relative steam consumption—see Example E. The low load factor for the auxiliary power

FIG. 8. PROBLEM E

Example E.

Conditions: – Plant Load; Average, 100 per cent; maximum, 167 per cent; and minimum, 75 per cent.
Main equipment to carry average load at full equipment rating and overload to 125 per cent of plant's average load.
Auxiliary equipment to carry peaks from 125 per cent of average plant load to maximum plant load of 167 per cent; at 50 per cent and 125 per cent of auxiliary equipment rating respectively.

Assumption: – Steam economy of auxiliary equipment the same as that of main equipment.

Required: – Average relative steam consumption of plant, steam consumption of main equipment being 100 per cent at average plant load and of auxiliary equipment being 33.6 per cent at full rating of auxiliary equipment.

Main Equipment

| Load | Relative Steam Consumption |
|---|---|
| 75.00 per cent | 2 x 101.50 = 203.00 |
| 91.70 | 3 x 100.22 = 300.66 |
| 100.00 | 1 x 100.00 = 100.00 |
| 108.40 | 3 x 100.60 = 301.80 |
| 116.80 | 1 x 102.17 = 102.17 |
| 125.00 | 3 x 105.00 = 315.00 |
| | 13 1322.63 |

Average Steam Consumption ----------101.74 per cent.

Auxiliary Equipment

| Load | Relative Steam Consumption |
|---|---|
| 50.00 per cent | 0.336 x 2 x 109.50 = 73.68 |
| 125.00 | 0.336 x 1/3 x 105.00 = 35.28 |
| | 108.86 |

Average Steam Consumption ----------36.29 per cent.

Plant's Average Relative Steam Consumption = $\frac{1322.63 + 108.86}{13}$

= 110.11 per cent.

Note: – Data the same as that for Fig. 1.

equipment must necessarily cause the relative steam consumption of such supplementary equipment to be comparatively high, being in use but a relatively short time and the load range comparatively wide no matter how carefully the auxiliary equipment may be proportioned to its load, the load balanced to the engines. Taking due account of the steam consumption of the auxiliary equipment, even though the rate of consumption should be no greater than for the main units, the plant's average relative steam consumption would be considerably greater than when no auxiliary equipment was employed and the whole load range of 223 per cent cared for without aid of extra engines.

Though complicating the power equipment of the plant, the addition of extra engines for caring for peaks would result in a reduction in the capacity or size of the main power units required of 25 per cent, but auxiliary equipment capable of caring for 33.6 per cent of that of the smaller main units would have to be installed, so that there would be no net saving in the total horsepower of equipment that would have to be supplied for the plant. Any possible gain from the use of smaller power units would be counteracted by the greater initial cost of equipment, which would be considerably more expensive than would the purchase of one general set of main units for caring for the whole range of power. Besides the drawbacks mentioned would be the quite considerable increase in cost of operation. There would be increased labor charges in all probability and certainly an appreciable increase in expenses for supplies, etc. The most serious increase in expense, however, would be that entailed in the greater steam consumption of the more complicated plant. Even if all equipment were equally economical in the use of steam and as sparing in its use as would be the larger power units of the simpler plant, there would be an increase of about 7½ per cent in steam consumption. It would therefore be an unwise and uneconomical move to complicate the plant by installing special engines for handling the peak and thereby enabling operation on smaller or fewer main units, notwithstanding the load range of 223 per cent which might be considered excessive for one set of equipment to handle.

Quite frequently instances may be encountered where the economic selection of power equipment as indicated by charts may not prove to be the best that could be made, but this is nearly invariably due to difficulty of properly balancing the load to the engine. The charts are not infallible, judgment must be used, but they do prove of considerable assistance in arriving at the advisable proportioning of the power equipment of a plant, or in correctly apportioning the load to the power equipment, and in ascertaining whether or not it would prove economical to install auxiliary equipment for handling peaks. For new installations, the lack of typical load characteristic curves of the plant when in actual operation proves a drawback, but there is always some precedence to work upon—other plants can always be found as models—and the charts will assist in evading blunders and errors made by others. Mistakes that could otherwise be avoided only by careful, long and tedious investigations can easily be steered clear of, rapidly and easily, by the use of a set of charts such as have been presented in this discussion.

# Boiler Feed Water---I

EFFECT OF TEMPERATURE, PRESSURE AND FORCING ON INCRUSTATION
RELATION OF DENSITY TO FEED WATER VALUE. BY F. F. VATER

CONSERVATION OF NATURAL resources is being given more thought each year, and the necessity for this will become more and more apparent as time passes. Much work is being done along this line that is not talked about, nor in print, hence a great deal that has been and is being accomplished, is not known.

Keeping boilers clean is the essence of conservation. Twenty or more years ago, boiler feed waters were accepted as they were found. The loss caused by the use of poor waters was also accepted as inevitable and the bills were paid without question. In the past boiler pressures were low as compared with those of today, boilers were not worked hard, as a rule, and water that was used then cannot now be used. If the rated capacity was obtained, the user was satisfied.

Today, the effort seems to be to get every pound of steam out of a boiler that the heating surface it contains will deliver. You, therefore, read of tests showing boilers are evaporating 150 to 200 per cent of their rating.

Higher pressure and heavier duty is true conservation, because it permits you to obtain 1000 hp. of steam on an investment in a 500-hp. boiler. It, therefore, means less investment in prime movers, in buildings and in ground space occupied, which facts have a vital bearing on the quality of water which can be used for boiler-feed purposes.

## EFFECT OF FORCING ON INCRUSTATION

TAKE THE sludge from a boiler, composed of carbonate of lime and magnesia with 15 per cent sulphate of lime in it, compress it under 80 lb. pressure per square inch, heat to 323 deg. F. (the temperature of steam at 80 lb. pressure), and you will have formed a briquette. It will, however, disintegrate readily. Take the same substances, compress them under 165 lb. pressure per square inch, heat to 372 deg. F. (the temperature of steam at 165 lb. pressure), and you will have formed a briquette that is hard to disintegrate.

If you are working a 500-hp. boiler to 500 hp., and are evaporating a water containing 15 grains of incrusting matter per gallon, you will deposit in an hour's run, 4.3 lb. of solid matter. If this 500-hp. boiler is worked to 750 hp., you will deposit in an hour's run, 6.45 lb. of solid matter, which is the equivalent of evaporating a 22½-grain water in the boiler at its rating.

Using a water containing 15 grains of incrustants at 80 lb. pressure, and at rated load, no serious trouble will follow. But use water containing 15 grains of incrustants under 165 lb. pressure, and no overload, and you are in trouble. Use a 15-grain water at 75 to 100 per cent overload, 165 lb. pressure, and your trouble will be serious.

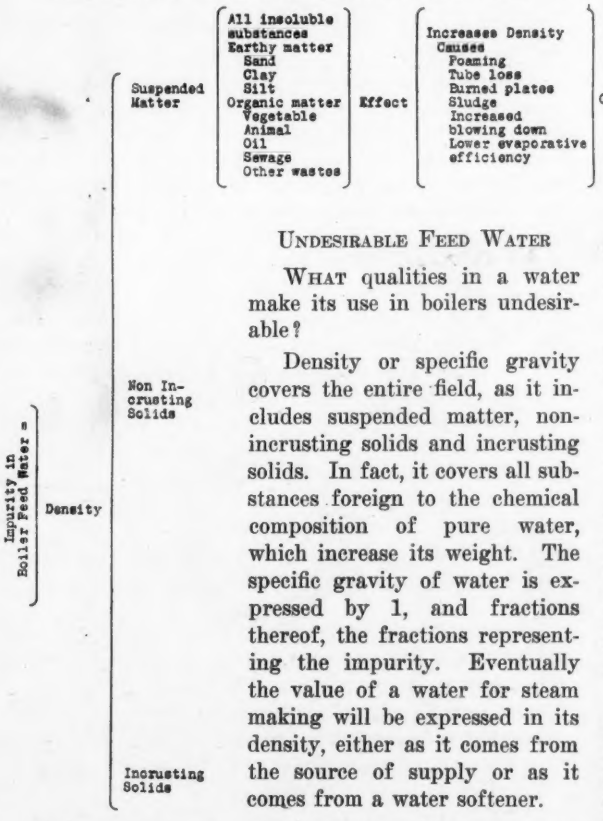
A water-softening equipment is now being installed where the water used contains but 2.8 grains of incrusting matter per gallon; but 21 per cent of this incrusting matter is lime sulphate, and the boilers will never operate at less than 125 per cent of rating and at

peak loads will develop 250 per cent of rating. It is this change in operating conditions that has created a demand for water softeners and the demand will continue to grow until no plant of 300 hp. or larger using a water containing not more than 8 grains of incrustants, but will be equipped with its water softener.

The reason is obvious. It is conservation. If I can save in coal, save in labor, save in repairs, save in compound bills, save in deterioration in settings, a sufficient sum of money to cover interest and depreciation, labor cost and chemical cost of operating a water softener and have 10 or 20 per cent annual dividends on my investment left, I can't afford to do without it; neither can any steam user.

That 15 or 20 per cent dividends on the investment is a conservative statement, I will show later, and permit me to say here, any illustrations given herein are not theoretical but are actual, having come under my observation in plants in actual daily operation.

THE START OF A FEED WATER TREATMENT CHART




## Undesirable Feed Water

What qualities in a water make its use in boilers undesirable?

Density or specific gravity covers the entire field, as it includes suspended matter, nonincrusting solids and incrusting solids. In fact, it covers all substances foreign to the chemical composition of pure water, which increase its weight. The specific gravity of water is expressed by 1, and fractions thereof, the fractions representing the impurity. Eventually the value of a water for steam making will be expressed in its density, either as it comes from the source of supply or as it comes from a water softener.

Distilled water, free from any impurity, has a density of 1. As you add to a distilled water 1 grain of impurity, whether this impurity consists of incrusting solids, nonincrusting solids or suspended matter, you have increased its density. To the extent that the density has been increased, you have rendered it that much less valuable as a medium for the production of steam.

## Treatment Chart

It is fair to presume that being a reader of Practical Engineer, you are busy and have no time to waste. Inasmuch as valuable data will be given you that will be worth referring to, you can save time by charting or expressing, in graphic form, the whole story so that a glance will refresh your memory.

Take a sheet of paper, say, 12 by 24 in.; don't be afraid of getting it too large and in the center of the sheet from top to bottom and at the extreme left-hand side of the page write as in Fig. 1:

Impurity in Boiler Feed Water = Density.

Now bracket from the word Density, by drawing a line from the bottom to the top of the page.

Opposite the word Density, write, Nonincrusting Solids. Halfway to the top, write, Suspended Matter. Halfway to the bottom write, Incrusting Solids.

The chart being started, let's get a few simple facts clearly in mind, so that we may not get lost.

Chemically expressed, water is $H_2O$, which means that it is composed of 2 atoms of hydrogen and 1 atom of oxygen. This is absolutely pure water. It has no substance in it foreign to its chemical composition. Its density is 1.

Water used in boilers contains matter foreign to its nature, and for convenience, we will classify them as Suspended Matter, Nonincrusting Solids, Incrusting Solids, as given for the beginning of the chart.

The unit of weight of water is one pound. This pound being divided into 7000 parts, each part will be one grain. One grain, therefore, weighs one seven-thousandth part of a pound.

The unit of measure of water is the gallon. A gallon weighs 8⅓ lb., and as there are 7000 grains to a pound, a gallon of water weighs 58,331 grains.

One grain of water, of lead, of lime, of carbonic acid, of chlorine or of soda weighs the same. The bulk, of course, varies.

Get this clearly in your mind. A grain of any substance weighs the same. There are 58,331 grains in a gallon of water at a temperature of 39.1 deg. F., its point of greatest density. We will neglect any correction of weight due to difference in temperature to avoid complication, but all calculations will be based on a temperature of 62 deg. F., at which point, a cubic foot weighs 62.355 lb.

One grain of any substance added to one gallon of water will increase the weight of the water one grain or one fifty-eight thousand three hundred thirty-first part of a pound. To show the relation of grains of impurity per gallon to density, we will take a striking case.

The density of Sea Water varies from 1.026 to 1.03. Having a density of 1.026, it will contain 1516.6 grains of impurity per gallon. At a density of 1.03, it will contain 1749.93 grains of impurity per gallon.

Figure this yourself; in the case of 1.026, you simply multiply 58,331 grains per gallon by 0.026, giving you the quantity of impurity stated above. Now figure it the other way, 1516.6 divided by 58,331 gives 0.026 and as pure water is 1, your sea water density is 1.026, or its weight is 59,847.6 grains per gallon.

Getting back to our chart, we have classified density into 3 parts, namely, Suspended Matter (call it organic

matter, if you prefer), Nonincrusting, and Incrusting Solids.

In order that our foundation be broad enough to carry the superstructure, we will define these 3 parts by dividing each one again into, and naming, the several substances ordinarily found in water used for boiler feed.

Any matter in suspension necessarily is of such a nature that it will not dissolve in the water or go into solution. Generally, matter in suspension is visible to the eye. If the particles are very finely divided, it may show only as a discoloration. Suspended matter consists of all earthy substances such as clay, sand and silt, insoluble in water. It consists also of organic matter, such as all forms of vegetable life, dead or alive, animal life such as small fish, water fleas or other forms. It includes oil or other forms of grease, of sewage or other wastes which are insoluble in water.

Take our chart now and place a bracket after the words, Suspended Matter, and write all insoluble substances, earthly matter, as sand, clay and silt, organic matter or vegetable or animal life, oil, sewage or other wastes.

Reverse your bracket to include the above and write, Effect. Bracket from this word and write increases density, causes reduced evaporative efficiency, foaming, increased sludge, loss of tubes in water-tube boilers, and loss of plates in return tubulars, increased blowing down.

Reverse bracket this, and write Cure. Bracket from this word and write as the cure, Sedimentation, Filtration or Both.

You now have a chart nicely started, but bear in mind the fact that the effect and cure are given without considering their relation to the other impurities water contains, such as, the nonincrusting and incrusting solids. This relation will be referred to later.

(To be continued.)

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EVERY NOW and then the circumstances attending an explosion are of such a nature that they permit us to reconstruct by inductive reasoning some portion of the rapid succession of events. In accordance with the Colburn-Clark theory, a rupture below the water line *need* not be attended with violent results, while if the rupture is *below* but *near* it should be possible for both sorts of action to take place, first an outflow of water without violent disruption of the boiler until the water line is lowered to the immediate neighborhood of the break, followed by a violent explosion when that point is reached. This possibility is in no way at variance with that type of explosion where a large rupture takes place well below the water line in say, a vertical boiler, and the reaction of the issuing jet of steam and water is so great that it lifts the boiler bodily, projecting it to a considerable distance, exactly as the issuing stream of water or steam propels a turbine wheel, or the issuing gases propel a sky-rocket, for in this latter case the explosion is not violent in the sense that the boiler is torn and disrupted as if by a blow, but is only the natural consequence of the powerful jet action following a very rapid outflow below the water line.—The Locomotive.

# Heating the Grand Central Terminal*

INTERESTING FEATURES OF THE HOT WATER SYSTEM. BY W. G. CARLTON

THE system is divided into 3 levels, low pressure, from 8 ft. to 170 ft. high, intermediate pressure, from 170 ft. to 288 ft., high pressure, from 288 ft. to 395 ft. Heaters, which are located near the pumps, are of surface condenser type, containing 1871 tubes, ¾ in. in diameter, and 15 ft. long. Two heaters are used on the low pressure system, and one each on intermediate and high pressure systems. Live steam is supplied to the heaters when necessary, but the greater part is exhaust steam from various machines, a considerable part being from 3 500-kw. generating units, which are part of the terminal light and power equipment. The balance of the power for the terminal is supplied by rotary converters, which have sufficient capacity so that the turbines are run only when the exhaust steam is needed for heating purposes.

Circulation is furnished by centrifugal pumps, 14 in., single stage, direct connected to 175-hp. motors, with speed variable from 500 to 1000 r.p.m. Each pump has a capacity of 500 g.p.m. against 100 ft. head, the combined efficiency of pump and motor being about 60 per cent. The low-pressure system has 4 pumps, intermediate 2, and the high 2, but only 3 motors have, up to the present, been required on the low pressure load, and one each on intermediate and high pressure systems. The distributing mains are 18-in. pipe, with Van Stone joints, having Klingerit gaskets, and have given no trouble with leaks. Practically all pipes are in pipe galleries, and easily accessible for necessary repairs.

The service rendered is measured by Venturi meters, one in each of the 3 main lines, called master meters, and other meters at each building where service is given, and for each kind of service. Recording thermometers are installed with each meter, and the total of the readings obtained from the 15 meters on the building services checks closely with the measurement from the 3 master meters.

Regulation of the heat furnished can be controlled by varying either the temperature of the water or the amount of water circulated. During the colder part of winter, most of the regulation is by means of changing temperature, the engineer having a table showing the outgoing temperature of the water from the plant for each given outdoor temperature. The maximum drop between supply and return mains for the coldest weather is about 25 deg., and the average drop for the colder months about 16 deg. The low pressure system requires a maximum circulation of 6000 gal. a minute, the intermediate 2300 gal., the high pressure 1200 gal.

Charges are made on the basis of 1,000,000 B.t.u., which is approximately equal to 1000 lb. of steam, the rates being on a sliding scale, and the heat furnished computed from the amount of water and the difference in temperature between supply and return.

The building has some 50,000,000 cu. ft. of space, partly for railroad uses, partly for hotel, club, exhibi-

*Abstract of paper and discussion before the N. D. H. A. convention.

tion and general office room, and about 600,000 sq. ft. of heating surface is installed, the total heat delivered to the buildings during the heating season being not far from 250,000 units of 1,000,000 B.t.u. each.

In the course of the discussion, Mr. Carlton stated, that extra heavy fittings were used on the high pressure system, although the pressure carried is no greater than that due to the static head. The heating and ventilation for larger spaces is accomplished by means of hot water coils and fans. He stated that there was no difficulty in the measurement of hot water by the use of Venturi meters, but that for very small sizes of these meters, sediment in the water might cause some incrustation, which would have an effect on the measurement, and the expense of the Venturi meters would be too great to permit of their use for metering the supply to small customers.

In reply to a question, he stated that the use of the Venturi meters and the thermometers to determine the B.t.u., involved a considerable amount of figuring, but that it so happened that they had a man who was of necessity on duty at all times, but who had sufficient free time so that this figuring could be done by him without any increased expense in operation. The Venturi meter readings were guaranteed accurate within 2 per cent, but even if they were somewhat out in recording the flow, the error would be practically constant, so that the relative readings would be correct.

# Underground Steam Mains

### Multicell Construction of Conduit and Pipe Insulation and Provision for Expansion

THIS system provides for a conduit built up of hard burned terra cotta tile having air ducts about 2 by 3 in., the tile being 4 in. thick and of sizes to give the required size conduit, the whole being carried by a continuous reinforced concrete base 4 in. thick.

#### Drainage

Beneath this base, a 4-in. drain tile is installed, properly graded and connected to the sewer system or other outlet so as to carry away seepage or leaks and keep the conduit dry at all times. The upper side of

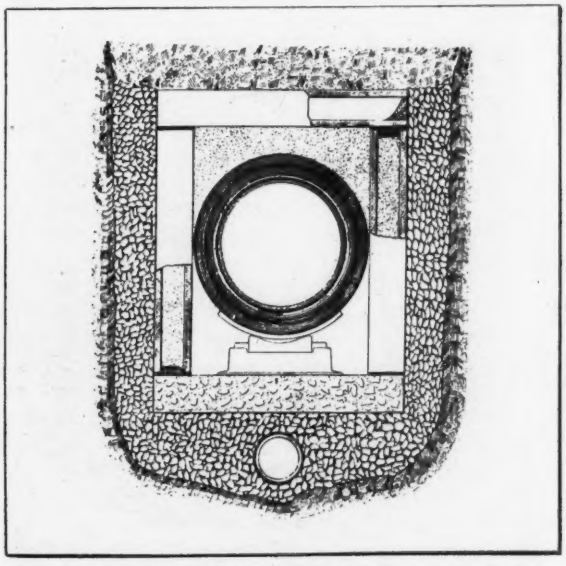


FIG. 1. CROSS-SECTION OF STEAM MAIN IN MULTICELL CONDUIT

the drain tile is kept 9 in. below the underside of the conduit system where variators are used for expansion, and 3 in. below where expansion joints are used. If the steam line is larger than 5-in. pipe, 2 lines of drain tile are installed.

Around the drain, below the concrete base of the conduit and at the sides, crushed stone or coarse screened gravel is filled in, unless the character of the soil makes such tile and filling unnecessary.

In putting down the system, the drain tile is first laid in its bed of crushed stone, then covered in, and the concrete base of the conduit built in place. Upon this concrete, cast-iron chairs are spaced at a distance

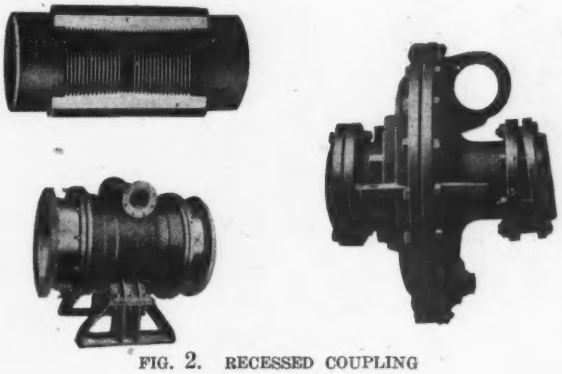


FIG. 2. RECESSED COUPLING
FIG. 3. DOUBLE EXPANSION JOINT
FIG. 4. SINGLE VARIATOR

of not over 12 ft., having rollers on which cast-iron saddles move to carry the pipe, giving free movement for expansion and contraction and insuring proper alinement.

FIG. 5. ANCHOR SPECIAL, COLLAR AND ANGLE JOINT

On these saddles, rest the pipe which is provided with sectional covering, prongs on the saddles reaching through the covering and taking the weight of the pipe direct, so that the covering is not crushed or packed.

#### Pipe Lines

Piping is of wrought iron having ends joined by welding or long recessed couplings. Each length is to be tested for tightness under 500 lb. hydraulic pressure. Joints to fittings, except variators, are by standard fit-

tings faced and drilled and having corrugated copper ring gaskets, and fittings are of special long sweep design, and with eccentric openings at reducing branches to insure drainage of condensation. Valves on the mains are of packingless type with double gates and stem operated by square nut or handwheel.

Cast-iron pipe is sometimes used and is of thickness suitable for the pressure carried, with threaded joints or cast flanges.

As it is laid, the pipe is fitted with a special insulating covering, built up in section and of 2-in. thickness for pressures of 25 lb. or less, and 3 in. above 25 lb. Outside the sectional covering are applied 2 layers of asphalted waterproofing, the layers breaking joints and all laps cemented with liquid asphalt or its equal. The outside is given a coat of black waterproof varnish and the line is then ready for covering in with the conduit.

### Multicell Conduit

The side tiles with the air ducts as shown are placed with lower ends bedded in cement mortar on the concrete base. Then the upper ends are covered with cement, the roof tiles firmly bedded on this, and the open ends of the roof tiles sealed with cement mortar, standard grades of American Portland cement being used. This gives a permanent, durable, water-tight conduit surrounding the main throughout. At points where variators, or anchor special connections are to be provided, boxes are formed in the conduit as indicated by the sectional views, the method of construction being the same as for the conduit, except that the top of the box is of planking covered with tar paper and a layer of tile, to permit of ready removal, should examination or repair become necessary.

### Expansion and Anchorage

With variator construction, anchor fittings and variators alternate, the distance between being not over 51 ft. On mains installed in sections, with only occasional connections for buildings, the distance from anchor to expansion joint is not over 120 to 260 ft., according to size of pipe.

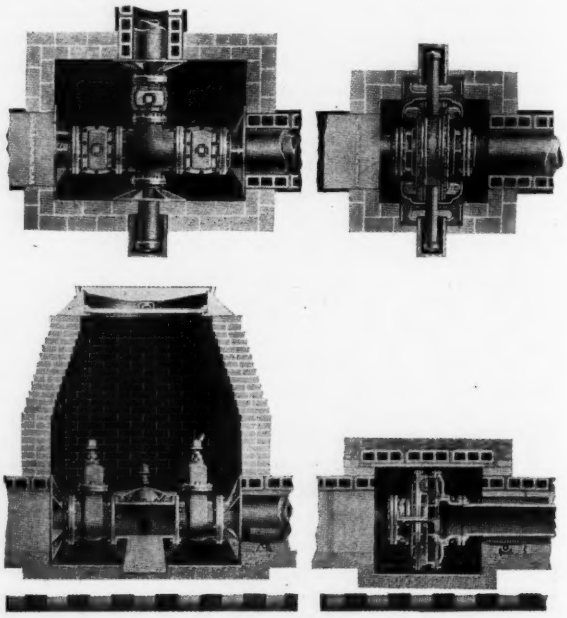


FIG. 8. SECTION OF PLAN AND ELEVATION OF VARIATOR BOX AND BRANCH MANHOLE

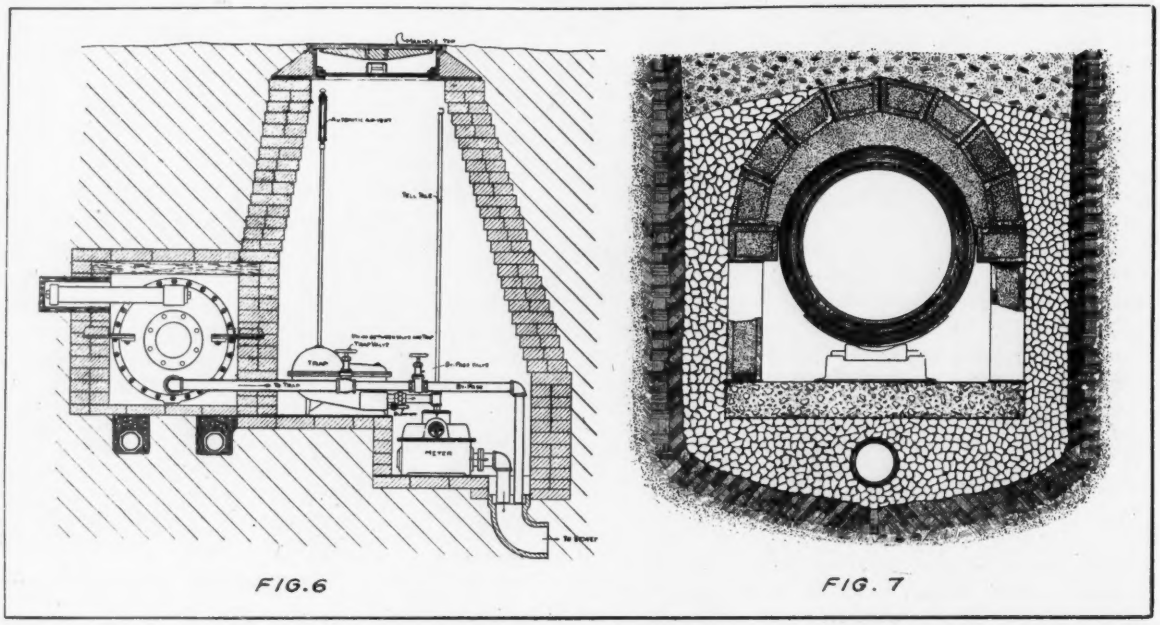



FIG. 6. MANHOLE WITH STREET TRAP AND METER INSTALLATION

FIG. 7. ARCHED CONDUIT CONSTRUCTION

Expansion joints are of brass slip joint type special design, and as they require packing at intervals, they are installed in manholes, usually of brick construction; also, manholes are provided where branch mains are taken off, to permit manipulation of valves. Anchor specials and street corner specials are securely anchored to the walls or base of the conduit by side or bottom plates built in, and have cast-iron collars butting against

the end of the conduit. Also service connections are led off at sweep right angles to the fittings, with nipples extending through the masonry and capped. Changes in grade or alinement are made at anchorage points by means of special angle flange joint fittings. The service connections are taken from the top of the main, *except* where drainage of the mains is needed, when the connections are to the bottom of the main with traps on the customer's supply line.

### Drainage Traps

At low points in the mains, automatic low-pressure traps are provided, located in manholes and fitted with long pattern automatic air valves, bypass and control valves, and draining to the sewer. A tell-tale is used to show when a trap is blowing steam, and when possible, a street condensation meter is used to record the trap discharge.

Manholes have an inside diameter of not less than 18 in. and if 2 or more valves are in a manhole, the inside diameter of the opening is made of size to allow operating the valves with extension wrenches. Double cast-iron covers are used, the inner cover being packed water tight to keep out surface water, and the outside cover being strong enough to carry safely a load of 5 tons.

After the conduit is completed and the drainage fill in place, the trenches are backfilled with dry earth well tamped to a level at least a foot above the top of the conduit, care being taken before backfilling that all leaks from water pipes or sewer pipes are remedied.

Where mains 18 in. or over are used, the conduits are built with the roof of arch form from special tile to give the required strength.

This method of insulating underground steam mains is one of the 2 methods used by the American District Steam Co., of North Tonawanda, N. Y., and from very extensive tests covering a long period of years, they claim a very high insulating efficiency.

# Efficient Operation of Boiler Rooms

### A Show Plant Which Lacks Instruments to Aid Firemen

In an isolated factory power plant, commonly referred to in the community as a show plant, conditions for efficient operation are just short of ideal; but up to the time of the writer's visit, little had been done towards bringing up the efficiency of the plant. The engine room is palatial; tile floors and walls beautifully designed; brass rails kept highly polished; the switchboard is a masterpiece of mechanical art; engines and generators are impressive both as to size and excellent condition in which they are kept.

All this in the engine room would impress the average visitor that here is a plant where the best of results are obtained. In the boiler room—well only a few visitors care to see that because boiler rooms are usually so dirty and hot, so not so much time and work are put in keeping things in show condition. The equipment, however, is of a highly efficient type and without question is giving good results, but nobody knows how good except in a general way. The firemen use their best judgment in handling fires; no other aid is available; no draft gages are provided, nor coal scales, nor means for determining load on individual boilers. A $CO_2$ recorder, however, attached to the stack breeching helps some by giving over all results.

Steam generating equipment consists of 11 400-hp. Wickes boilers, worked at 160 lb. pressure, with standard Wickes settings. These are operated at approximately full load during off peak periods, but no extra boilers are thrown in to take care of peaks; the load, however, is quite uniform during the day, increasing to a peak when the lights are needed.

All boilers are served by Murphy dutch oven furnaces and stokers which have a projected area of 80 sq. ft., making the proportion of heating surface to grate surface 50 to 1.

The water columns are all equipped with high and low water alarms and the firemen are instructed to blow them down every 8 hr. The sketch shows a special method of connecting the columns to the drum which prevents the water in the glass from surging which was quite common when the water connection did not extend beyond the water baffle.

The feed water connection is to the bottom drum without any inside piping. Each boiler is provided with a surface and a bottom blowoff piping in which are placed a blowoff valve and a cock for protection. The bottom blowoffs are opened at night when the pressure is low, but the surface blowoff is seldom used as the water does not contain floating precipitates.

Two 4½-in. Crane spring loaded safety valves are placed on each boiler, one each side of the main steam line, and the outlet is connected to blow outside the boiler room.

Run of mine bituminous coal is used which is bought from a city dealer. The heating value is not known. They aim to carry 4 to 5 in. of fuel over the grate bars but the exact rate of combustion is not known as no means for determining it under operating conditions have been provided.

Draft is regulated by hand and has been determined by occasional tests to be from 0.12 to 0.22 in. over the fire, about 0.67 in. on the boiler side of the damper when 1 in. at the base of the stack.

The consumption of coal is estimated daily, no means of weighing the coal as used being provided. A water meter is being installed to measure the amount fed to the boilers. Steam to the heating system will be measured by a steam flow meter though at present no provision is made.

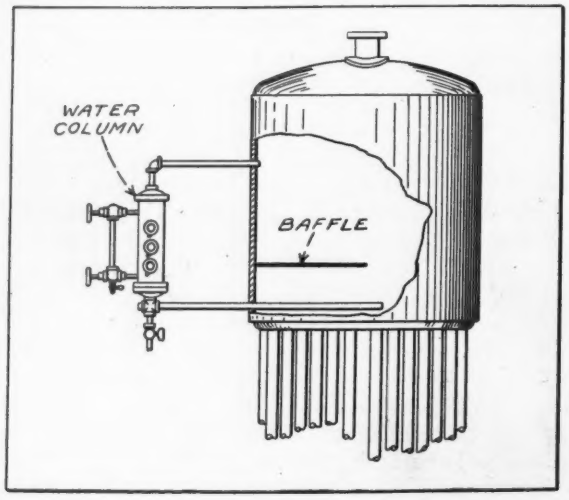
The feed water temperature is read regularly and varies from 160 to 170 deg. Flue gas temperature is taken occasionally and reported at from 300 to 500 deg. A $CO_2$ recorder gives the average percentage of $CO_2$ in the flue gases as 12, but under tests analyses have shown as high as 15 and 16 per cent.

No treatment whatever is used for the feed water as the great share of it is the returns from the heating system, lake water being used to make up losses.

When a boiler has been cut out of service for cleaning it stands for 24 to 40 hr. before it is opened, then it is washed down with cold water, after which a turbine is run through the tubes, but very little scale is found as each boiler is cleaned every 4 or 5 weeks. While out of service the boiler is inspected thoroughly for bags, blister and other defects. Before being put back into service the boiler is subjected to a water pressure equal to that at which it is operated and all joints are carefully examined for leaks.

Soot is blown from the tubes every 24 hr. by means of an air pipe with a perforated nozzle carrying 80 lb. pressure.

Coal from the yard is delivered by a bucket elevator to a screw conveyor over the bunker which extends the entire length of the boiler room and has a capacity of 750 tons. From the bunker chutes discharge the coal to the stoker hoppers.




WATER COLUMN PIPING WHICH AVOIDS SURGING IN GAGE GLASS

Beneath the furnaces concrete ash hoppers catch the refuse and discharge it to metal wheelbarrows kept always in this location, except when dumping. Ashes are wheeled to a bucket elevator and discharged into a storage, thence to a railway car.

The boiler attendants are instructed to watch for cracks and when any part of the setting looks suspicious it is examined with a match or candle; occasionally the damper is closed for a few seconds while the fire is strong and the setting is watched for escaping gases.

The boiler room force is divided into 3 shifts, there being 13 men in the first, 8 in the second, and 3 in the night shift.

A system of accounts has just been installed in this plant which should prove of value in placing the costs of the various services where they belong. With the addition of a few instruments in the boiler room this plant would be in shape to analyze results and raise its efficiency to a maximum and keep it there.

THE CHAMBER OF COMMERCE of the United States has felt that the question of some action on a Merchant Marine for this country was of importance sufficient to warrant the sending out of a referendum ballot on various propositions which have been made by the government of the country, and also on several propositions made by the Chamber of Commerce. A brief summary will be of interest, as showing the feeling in regard to the matters. The canvass extended to every state in the Union, the vote being by members of the Chamber of Commerce. This membership consists of Chambers of Commerce of the various cities, banks and manufacturing organizations, and like bodies.

On the question of purchase, construction or charter of vessels by the government, and the operation of such vessels, 698 opposed and 82 favored. On the question of ownership of merchant vessels, to be leased to private parties for operation, 711 opposed and 54 favored. On the question of government subsidies to offset the difference in cost between operation of vessels under the American flag and under foreign flags, 558 favored and 186 opposed. On the question of subventions to establish regular mail and freight lines under the American flag to countries with which our commercial relations are important, 718 favored and 48 opposed.

The second ballot on recommendations made by the Chamber of Commerce's special committee, resulted as follows:

On the creation of a federal shipping board to investigate and report to Congress, and have full jurisdiction, under the navigation laws, in all matters pertaining to over-sea transportation, 645 favored and 116 opposed. On the question of organizing a marine development company, with a capital of $30,000,000, of which the government should subscribe for the entire stock, to loan money, under supervision of the federal shipping board, on mortgages on merchant vessels, and take bonds on the vessels, these bonds to be guaranteed and sold to the public, 422 favored and 314 opposed. On the amendment of the ocean-mail law, to lower the speed of first-class steamers from 20 to 16 knots, and for second-class steamers from 16 to 12 knots, and making the mail compensation sufficient to permit establishment of lines carrying both mail and freight, 690 favored and 66 opposed. On the question of abolishing deferred rebates, and providing for supervision of rates by the shipping board, and requiring the filing of all schedules of rates and all agreements among over-seat lines, 607 favored and 131 opposed. On the question of federal licenses required of both domestic and foreign lines engaged in shipping between ports of the United States and other countries, 616 favored and 121 opposed.

While the analysis by the officials of the Chamber of Commerce is not yet complete, the indication seems quite clear that government ownership and operation of vessels is not desired by the country, but that a large majority of the business men and business organizations favor some form of government assistance which shall permit the establishment of regular lines of United States steamers carrying mail and freight direct from the United States to foreign ports, the government shall exercise such control of these lines as will insure fair rates and competition, similar to the control of the railroads by the Interstate Commerce Commission.

# Electrical Machinery and Appliances

*For Generating, Transmitting and Using Current*

## Power Factor Effects

RESULT OF LOW POWER FACTOR; ITS MEASUREMENT; ITS VALUE IN VARIOUS TYPES OF APPARATUS

POWER output of direct-current generators or the power intake of direct-current motors may readily be obtained by multiplying together the voltmeter and ammeter readings at any particular instant. Such, however, is not the case when considering alternating-current generators, motors, transformers and other apparatus. An alternating-current generator may at any time appear, from its volt and ammeter readings, to be carrying full load, when, in reality, if a wattmeter be used we may find that the machine is delivering in kilowatts but, let us say, 75 per cent of its rated capacity.

When the load on an alternator consists principally of transformers or induction motors, we find that the current lags behind the electromotive force in phase; while, if the load has a condenser effect, such as produced by an over-excited synchronous motor, the current will lead the electromotive force. In either case, upon a comparison of voltmeter, ammeter and wattmeter readings we find that the apparent watts load, that obtained by multiplying the current flow in amperes by the electromotive force in volts, is greater than the actual watts load as indicated by the wattmeter. Let us assume a circuit carrying 130 amp. at a voltage of 110 and with the current lagging 20 deg.

From our ammeter readings we find that apparently 110 times 130, or 14,300 w. or 14.3 kw. are being delivered, but this is not the true number of watts or kilowatts. The true number of watts is found by multiplying the number of amperes by the volts and by a factor called the power factor whose value depends upon the size of the angle of lead or lag. While the value of the power factor may be obtained by resorting to the use of trigonometry, we may more readily and as accurately find its value by dividing the wattmeter reading by the product of the volt and ammeter readings expressed in watts. In other words, the power factor is the ratio between the true watts and the apparent watts. It is also represented by the cosine of the angle of lead or lag when the electromotive force and current waves are not distorted.

To distinguish one from the other, the apparent output, that is the product of the voltmeter and ammeter readings, is usually expressed as kilovolt amperes, abbreviated kv.a., while the true output is expressed as watts.

Referring to the case cited above, we find that the actual power being delivered is equal to the product of the volts times the amperes times the cosine of 20 deg. This cosine value may be obtained from any table of natural trigonometric functions and, for 20 deg., is found to be 0.9396. We have, therefore, in this case, the true watts equal to 110 times 130 times 0.9396, or 13,436 w., or 13.436 kw.

Switchboards may be equipped with ammeters, voltmeters and power-factor meters, in which case the true watts may be obtained in the manner just shown, power factor meters indicating directly the per cent power factor, or, in other words, the cosine of the angle of lag or lead. Again, a board may not be supplied with a power factor meter but may have mounted upon it in addition to the regular voltmeters and ammeters, a

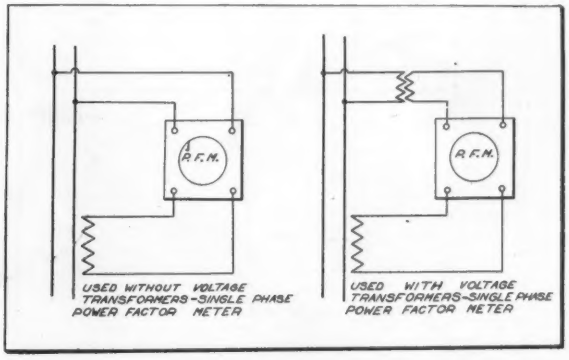

P.F.M.
USED WITHOUT VOLTAGE TRANSFORMERS-SINGLE PHASE POWER FACTOR METER
P.F.M.
USED WITH VOLTAGE TRANSFORMERS-SINGLE PHASE POWER FACTOR METER

FIG. 1. DIAGRAM OF CONNECTIONS OF POWER FACTOR METER ON SINGLE PHASE CIRCUIT

wattmeter or meters. Under such conditions the power factor may be determined by dividing the wattmeter reading expressed in watts by the product of the volt and ammeter readings. The quotient will represent the cosine of the angle of lead or lag or when multiplied by 100 will give the per cent power factor.

Modern switchboards, especially those controlling large outputs, are generally equipped with voltmeters, ammeters, wattmeters or kilowatt meters and power-factor meters, so that an accurate check on the accuracy of the various instruments may easily be obtained by comparing the volt-ammeter, power-factor meter and wattmeter readings.

### Effect of Low Power Factor

A low power factor with current leading is as detrimental to the proper operation of a generating station or transmission system as is a low power factor with current lagging, although it is the latter which is generally met and which must be corrected.

With a system, the power factor of which is comparatively low, excessive generator, switchboard and transmission line capacity must be provided, entailing considerable additional expense. The size of generator windings required, the capacity of the ammeters and wattmeters and the size of the controlling switches, circuit breakers and transmission lines needed are directly proportional to the current flow which, in the case of a low power factor, becomes exceedingly great when compared to the number of watts or kilowatts actually being delivered.

An example may illustrate the truth of this more effectively. Let us consider a station of 2000 kw. capacity, operating at a normal power factor of 65 per cent. We know that with unity power factor, for full-load operation, the capacity of the station is 2000 kw. and with a generated voltage of 2300, the windings of the

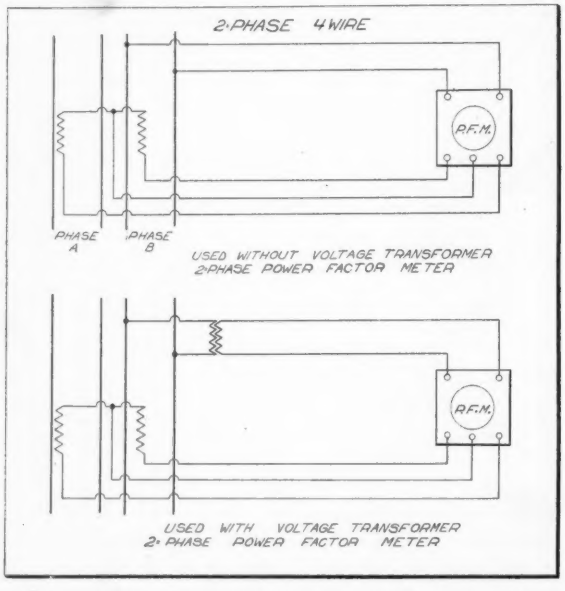



FIG. 2. DIAGRAM OF CONNECTIONS OF POWER FACTOR METER ON 2-PHASE CIRCUIT

machines, the size of the connecting cables, switches, ammeters, wattmeters, bus bars and outgoing lines need be no greater than is necessary to carry 2,000,000 divided by 2300, or 869 amp., and allowing for a small possible overload, let us say 1000 amp.

With a power factor of but 65 per cent and the station still called upon for 2000 kw., we find somewhat extraordinary requirements in the size of equipment. Under such conditions, the true watts are equal to 2,000,000, so that with the above-named power factor, the apparent watts must be 2,000,000 divided by 65 times 100, or 3,076,900 v.amp. or 3076.9 kv.a., and as the voltage remains constant an actual current flow of 3,076,900 divided by 2300, or 1337.7 amp. will exist. At normal rated capacity and unity power factor the generators and other equipment as outlined above have been designed for but a trifle over 869 amp., so that when operating at 65 per cent power factor this equipment will be called upon to carry an additional 486 amp. or 53.8 per cent more current than its normal rated capacity.

To remedy this trouble, it is necessary that a system be designed and equipped to operate at as high a power factor as is possible. Even under the best of conditions, power plant operators find it extremely difficult to maintain a power factor of exactly unity, hence, designers of power plant equipment have compromised by building and using machinery and apparatus of such capacity as will readily care for the load with a power factor at or above a given specified value. Present day designers of generating and transmission equipment allow for a minimum of approximately 80 or 85 per cent power factor, with the expectation that anything below this value shall be corrected beyond the switchboard.

Frequently, operators who do not understand the important role that high power factor plays in the operation of a generating station and transmission system, are extremely puzzled at the effects which a low power factor produces.

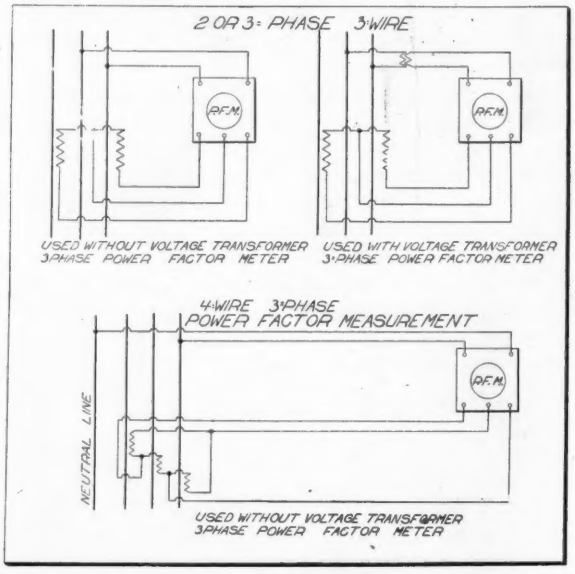



FIG. 3. DIAGRAM OF CONNECTIONS OF POWER FACTOR METER ON 3-PHASE CIRCUIT

Switchboard wattmeters or kilowatt meters may be indicating a normal load, while at the same time the generating unit may be showing all indications of carrying an extremely heavy overload, as evidenced by a slowing down of the prime mover and heating of the generators and of transformers when these are interposed between the machines and the load. Likewise, all cables, switchboard instruments, bus bars and transmission lines will be carrying a current greatly in excess of their rated capacity, resulting in a heating of all current carrying parts, and a considerable drop in voltage. This trouble may be of such magnitude as to cause the circuit breakers to open or, in the case of their failure, may even result in a burn out.

## Measurement of Power Factor

Power-factor meters perform, automatically, an operation that otherwise requires the simultaneous reading of 3 or more separate meters and the computation of the power factor from their indications. These meters indicate upon a graduated scale the power factor of the circuit to which they are connected.

A type of meter extensively used on 3-phase circuits consists of a field-current coil, connected in series with the middle line within which 2 potential coils are mounted on a vertical shaft. These coils are connected between the middle and outside lines. The resultant effort tending to deflect the shaft will vary with the power factor, because the phase relation of the currents in the movable coils to the current in the fixed coil will change with the power factor and the instrument can be calibrated so that the pointer attached to the movable coils will indicate the power factor.

Figure 2 illustrates the diagram of connections of another type of power factor meter for use on 2-phase circuits. The current in the series coils produces a rotating field while the current in the shunt coil produces an oscillating field. The shunt or electromotive force coil is free to rotate and will take up a position in which its oscillating field will be in time phase with the resultant rotating field in that plane. If the electromotive force is in phase with the current, the coil will take the position shown.

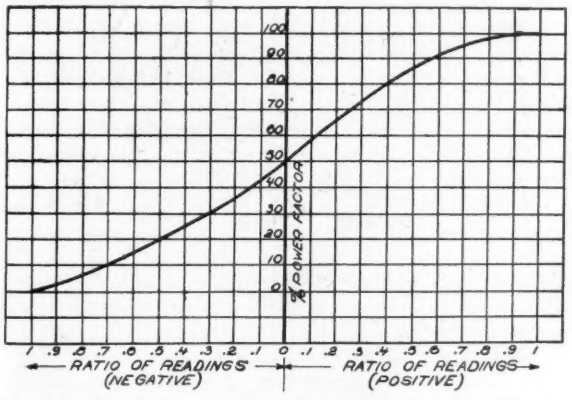



FIG. 4. RELATION OF RATIO OF WATTMETER READINGS TO POWER FACTOR

In the 3-phase type of this meter, the rotating field is produced by 3 coils spaced 120 deg. apart and connected to the 3 phases of the circuit; in the single-phase meter the relative position of voltage and current coils is reversed and the rotating field is produced by means of a split-phase winding.

A method employed to some extent in the determination of the power factor of a 3-phase circuit is by the 2-wattmeter method. With the meters connected in the regular manner, the power factor of the circuit may be determined by applying the ratio of their readings to the chart shown in Fig. 4. If this ratio should, for example, be 0.9, we find from the chart that the power factor is about 100 per cent; if the ratio is 0.4, the power factor is 80 per cent. If, however, one meter only indicates, the ratio of readings will consequently be 0, indicating a power factor of 50 per cent. Should, however, this ration be —0.4, due to a negative reading of one of the instruments, the power factor, instead of being 80 per cent as before, is approximately 24 per cent.

Let us assume the readings of 2 wattmeters connected to a 3-phase circuit to be 2000 and 6000 respectively, so that the ratio is 0.333. We would then find that, due to both readings being of like sign, causing 0.333 to be positive, the power factor is about 74 per cent.

Again, let us say that the readings be —2500 and +5000 watts. The ratio between the 2 values will be —0.5, so that by referring to the chart, we find a power factor of 0.20 per cent.

## Reactive Factor Meters

Another type of instrument now used extensively is the reactive factor meter, which instead of indicating the cosine of the angle of lag or lead as does the power factor meter, indicates the sine of the angle of lag or lead. This, in every case, is greater than the difference between unity and power factor, and therefore shows most emphatically the idle component of the voltamperes, thus inducing operators to correct more quickly the waste due to a poor power factor, and makes the use of these meters particularly desirable in the operation of rotary converters, where a slight drop in power factor will result in considerable armature heating.

With an angle of 10 deg., either lead or lag, the power factor will be 98.5 per cent, because the cosine of 10 deg. is 0.985, and the reactive factor will be 17.3 per cent, the sine of 10 deg. being 0.173, instead of 100

APPROXIMATE VALUES OF POWER FACTOR OF VARIOUS TYPES OF APPARATUS

| Apparatus | Per Cent Power Factor | Remarks |
|---|---|---|
| Incandescent Lighting | 90 to 95 | With small lowering transformers. |
| A. C. Inclosed Arc Lamps | 60 to 75 | With constant current transformers. |
| D. C. Metallic Arc Lamps | 55 to 70 | With rectifiers. |
| Single-Phase Induction Motor Squirrel Cage Rotor | | |
| ½ to 1 hp. | 55 to 75 | At rated load |
| 1 to 10 " | 75 to 86 | " " " |
| Polyphase Induction Motor Squirrel Cage Rotor | | |
| 1 to 10 hp. | 75 to 91 | At rated load |
| 10 to 50 " | 85 to 93 | " " " |
| Polyphase Induction Motor Phase Wound Rotor | | |
| 5 to 20 hp. | 80 to 89 | At rated load |
| 20 to 100 " | 82 to 90 | |
| Induction Motors (General) | 60 to 85 | Depending whether motors are carrying full load. |
| Arc Furnaces | 80 to 90 | |
| Induction Furnaces | 60 to 70 | |
| Welding Transformers | 50 to 70 | |
| Synchronous Motors | | Adjustment between practically zero power factor leading to zero power factor lagging. |
| Rotary Converters, Compound Wound | | Power factor at full load can be adjusted to practically 100 per cent. At light loads it will be lagging; and at overloads slightly leading. |
| Rotary Converters, Shunt Wound | | Power factor can be adjusted to any desired value and will be fairly constant at all loads with the same field rheostat adjustment. Should not be operated below 95 per cent power factor leading or lagging at full load or overload. |

minus 98.5, or 1.5 per cent, as may ordinarily be assumed. Likewise, with a power factor of 95 per cent, the reactive factor is 31.5 per cent, and not 5 per cent.

Power factor and reactive factor are equal at only 70.7 per cent. At higher power factors, the load conditions are more conspicuously indicated on reactive factor scale, while at lower power factor the reverse is true, and as a consequence, reactive factor indicators find their greater usefulness on circuits the power factors of which vary from 70 to 100 per cent.

### Power Factor of Apparatus

Typical power factor values for various types of apparatus as given by F. D. Newbury before the 1911 convention of the N. E. L. A., are given in the table.

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# Electrification of the Great Falls Terminal

As a forerunner of the 3000-v., main line electrification, the Chicago, Milwaukee & St. Paul Railway has recently begun electrical operation of the terminal line in the city of Great Falls, Montana. This city is at present the terminal of the new 138-mile feeder line from Lewistown, Montana, connecting with the main line transcontinental division at Harlowton, the eastern terminus of the 3000-v. electrification now under construction. The Great Falls terminal yards are located in the center of the city and are connected by a cross-town line, about 4 miles in length, known as the Valeria Way Line. There are about 3 miles of additional electrified trackage, making a total of 7 miles. The terminal buildings include a large freight house, round house, power plant and passenger station.

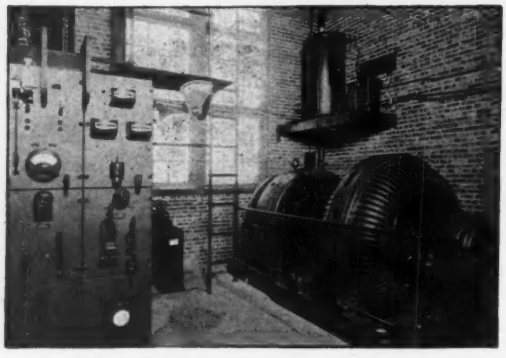

FIG. 1. 1500-V. SUBSTATION EQUIPMENT, GREAT FALLS ELECTRIFICATION, CHICAGO, MILWAUKEE & ST. PAUL RAILWAY

The tracks connecting the Falls Yards and the Terminal Yard pass through the business part of the city; and it is expected that considerable benefit will be derived from the elimination of steam locomotive smoke from the center of the city, as well as a reduction in the cost of train haulage. The traffic includes the transfer of both freight and passenger trains from the Fall Yards to the terminal station, as well as switching service in the terminals.

The electrical equipment is of sufficient capacity to take care of 580-ton freight trains operating at about 9½ mi. per hr. on the maximum grades of 0.65 per cent. Electric power is supplied by the Great Falls Power Co. from the hydroelectric plant at Rainbow Falls, about 6 mi. from the substation. Energy is transmitted at 6600 v., 3-phase, 60 cycles generated at the power station.

### Substation

The substation equipment is located in the power station operated by the railway company for heating the terminal buildings, and includes a 2-unit, synchronous motor-generator set with a 2-panel switchboard for controlling the alternating and direct-current units. The motor is rated 435-kv.a. (0.8 power factor), 6600 v., and operates at 900 r.p.m. Provision is made for starting as an induction motor through a compensator, which is operated from the alternating-current panel. The

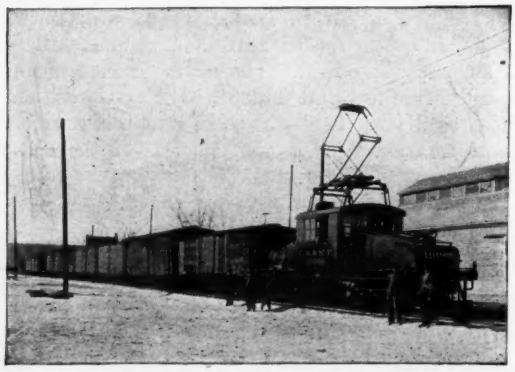

FIG. 2. 50-TON, 1500-V. ELECTRIC LOCOMOTIVE AND TRAIN, GREAT FALLS ELECTRIFICATION, CHICAGO, MILWAUKEE & ST. PAUL RAILWAY

generator is of the commutating pole type, rated 300 kw. at 1500 v. The set is capable of carrying 200 per cent overload, or 900 kw. momentarily. Excitation for the alternating-current motor fields and for the shunt fields of the direct-connected generator is furnished by a 10-kw., 125-v., direct-connected exciter.

The switchboard consists of 2 natural black slate panels, one controlling the synchronous motor and the other the direct-current generator and feeder. The direct-current panel is a standard 1500-v. type, carrying remote control, hand-operated switch and circuit breaker mounted between slate barriers at the top of the panel. The motor panel contains the usual instruments and starting and operating switches for controlling the motor. An aluminum cell lightning arrester is also installed in the station as a protection against electrical storms.

### Locomotive

All trains are handled by a standard, 50-ton electric locomotive of the steeple cab type, designed for slow speed freight and switching service. The running gear consists of 2 swivel equalized trucks, carried on semi-elliptic equalizer springs. The driving wheels are of solid rolled steel, 36 in. diameter.

The motor equipment includes 4 G. E.-207, 750 v., box-frame, commutating pole motors insulated for 1500 v. Each motor has a normal one-hour rating of 79 hp. at 750 v., and 2 motors are connected permanently in series. All motors are ventilated by a blower direct-connected to the dynamotor in the cab of the locomotive. The gear reduction is 64 to 17.

The control equipment is Sprague General Electric Type M., arranged for operation from either end of the cab. There are 10 steps with the motors in series and 7 steps in series-parallel. Control current for operating the contractors, lighting and other auxiliary circuits is furnished by a Type CDM-19, 1500/600-v. dynamotor. A multivane fan carried on an extension of the shaft furnishes air for ventilating the motors.

The current collector is a sliding pantograph, similar to that being installed on the main line 3000-v. locomotives. The slider is lifted into position by air pressure and is held against the wire by steel coil springs. Provision is made for operating at trolley heights varying from 17 to 25½ ft. above the top of the rail.

Compressed air for operating the air brakes, whistles and sanders is supplied by 2 CP-29, 1500-v. motor-driven air compressors, each of which has a displacement of 27 cu. ft. of air per minute at 90 lb. pressure. The compressors are located in the cab of the locomotive convenient for inspection.

A headlight, provided with a concentrated filament type Mazda lamp of about 100 candle power, is mounted on each end of the locomotive.

As a safety precaution, no trolley wire is installed inside of the round house. A connection is made in the cab of the locomotive for applying power to the locomotive through a length of special flexible cable insulated for 2400 v. A double-throw switch in the locomotive cab allows connection to be made either to the trolley or cable circuit.

### Line Construction

The overhead line construction is of the catenary type, similar in a general way to that installed on the Butte, Anaconda & Pacific 2400-v. railroad. Both span and bracket construction are used, depending on local conditions. Poles are spaced approximately 150 ft. apart on tangent track, supporting a 4/0 grooved trolley from a 3-point suspension. There is no feeder copper installed.

The work was done by the electrification department of the Chicago, Milwaukee & St. Paul Railroad, R. Beeuwkes, engineer-in-charge, under direction of C. A. Goodnow, assistant to the president. All of the electrical apparatus, including locomotive, substation equipment and line material, was furnished by the General Electric Co.

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Some idea of conditions in South America with regard to machinery and supplies of all kinds may be obtained from a recent consular report which states that a call for tenders for electrical material made recently by the Provincial Telegraph Department of Buenos Aires produced no offers. Firms that ordinarily would have bid for the contract were unable to do so because they had no goods in stock and no immediate prospect of receiving any owing to the war in Europe.

# The Inertia Governor Was O. K.

By N. G. Near

NO, I am not an inertia governor expert. I know very little about inertia governors except that they are founded on the doctrine of inertia.

"Inertia," our college professor used to say, "is the tendency of matter in motion to keep on moving in a straight line, and the tendency of matter at rest to remain at rest."

I once operated a high-speed engine equipped with one of the aforesaid inertia governors. When new the engine ran fine. I was so proud of it that I washed my overalls every day and wore a white collar in order that I might not besmirch the appearance and prowess of my engine with my once unseemly garments. A perfect engine, I argued, should have a perfect guardian. Day and night we ran that engine. The night engineer, I believe, was as proud of it as was I.

One year later, however, I detected something wrong. The voltmeter needle didn't stick to one number on the dial as well as it once did. It wandered here and there. It did no good to try regulating the voltage with the rheostat because the wanderings were of quite short duration. But, the fluctuations after several months became worse and as the needle swung hither and thither, I could hear a thumping in the engine and conceived, as I had for some time surmised, that the governor was "hunting."

I put thicker grease in the governor dashpot—grease that the above-mentioned college professor called "viscous fluid"—but of no avail. The governor WOULD hunt and the engine WOULD NOT run steady.

I took the flywheel off, and, like the small boy that I must have been and perhaps still am, I took the thing apart. The parts must have all been there, for it came apart easily, and went together again just as easily; and when all was back in place the governor still hunted and the engine still varied.

I studied the theory of inertia governors and learned only that my college professor was right. The basic theory is very simple. The inertia governor is the quickest acting of all. It depends neither on gravity nor on centrifugal force. It is very sensitive. The instant the speed varies, inertia causes the inertia weights either to lag or lead, and thereby either lengthen or shorten the stroke of the valve stem. Thus, more or less steam is admitted into the cylinder.

Finally, I wrote to the manufacturers of the engine; told them my troubles, and asked what I should do, and, believe me, I learned a mighty important and much needed lesson when this reply was received:

"Turn the flywheel to dead center, turn on the steam, look at the exhaust, and if you see that steam leaks through, your valve cylinder needs reboring and you need a new valve."

Steam leaked through as through the proverbial sieve. I should have been fired for wasting so much steam without knowing it.

I had the valve cylinder rebored, had a new valve fitted, just as instructed by the manufacturer, and lo and behold! the engine ran perfectly again. The governor had been O. K. all the time. The fault lay in me.

# GAS POWER APPARATUS

*Producers, Engines and Industrial Applications*

## Gas Blowing Engines

MONSTER UNITS WITH AUTOMATIC VALVES IN BLOWING CYLINDER

ADVANCE IN the design of blast furnace blowing equipment during the last 5 yr. has doubled. Rotative and piston speeds, complications in valve gearing have been eliminated, and perfection of automatic lubrication has materially reduced the cost of attendance and repairs. This progress is represented in the new gas blowing engines which the Mesta Machine Co. recently installed at the plant of the Pennsylvania Steel Co. in Steelton, Pa., having gas cylinders 46 in. diameter, air cylinders 84 in. diameter, and stroke 60 in.

As will be seen from the general view, Fig. 1, each of the engines consists of 2 gas cylinders and one blowing cylinder in tandem, the blowing cylinder being free from valve gearing, which makes possible the placing of the blowing cylinder back of the gas cylinder, and eliminates rods passing from the crosshead around the crank.

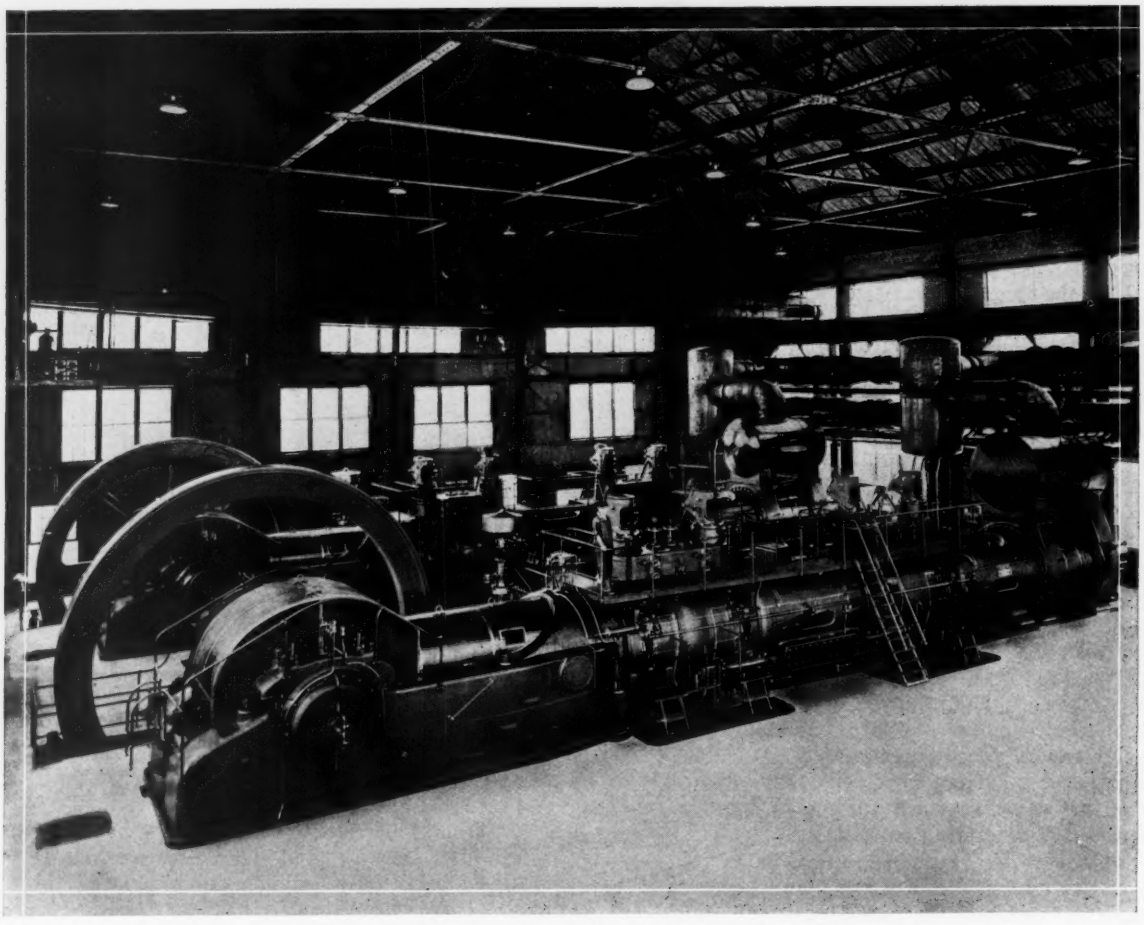

FIG. 1. GENERAL VIEW OF INSTALLATION OF GAS BLOWING ENGINES, 46 BY 60 AND 84 BY 60 IN.

The engine follows the recent tendency in gas blowing practice to make blowing engines of the single tandem design which is preferable from the standpoint of first cost and reduces to a minimum the number of moving parts which require attention.

Figure 2 shows the switchboard and the control hand wheels, and Fig. 3 shows the governor and the speed changing device. When the signal is received from the furnace to slow down the engine, a switch, thrown in at the control stand, changes the tension of the spring in the governor column and thus reduces the speed. As soon as the desired speed is obtained the switch is pulled out. "It beats the throttle all hollow," is the verdict of the operating engineers. The speed changing device, which is operated by motor drive, is provided with limit switches so that it is impossible for the engineer to exceed the speed change limit set by the designer of the engine.

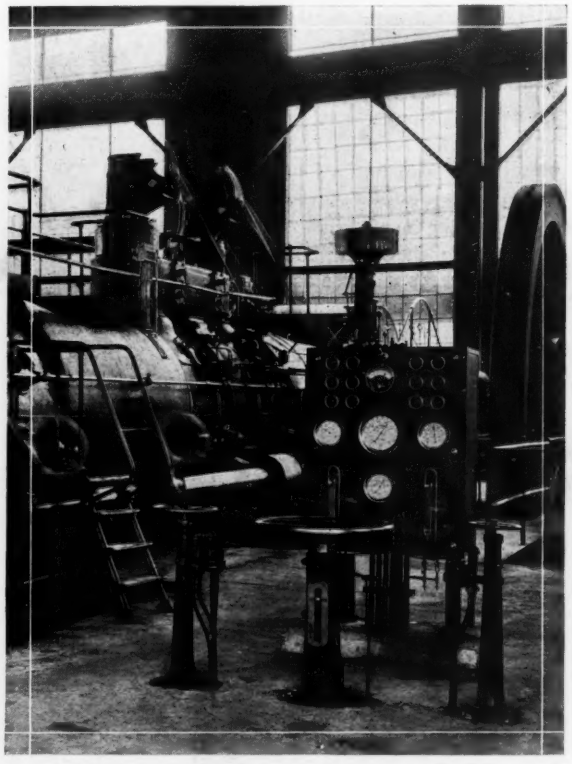

FIG. 2. CONTROL PANEL AND HAND WHEELS

Exhaust valves which are not water cooled, but the valve seat is cooled and the valve itself can transfer enough heat to the valve seat to protect itself. It has been said that a gas engine exhaust valve must withstand the action of a red-hot flame passing through it. Theoretical calculations and actual measurements show that the gases passing the exhaust valves are never hotter than 1100 to 1150 deg. F., unless combustion is sluggish during the explosion stroke and continues up to the time when the gases pass through the valve into the exhaust. With a correctly designed engine and ordinary care in operation, combustion is completed before the exhaust valve opens so that water cooling becomes wholly unnecessary.

Oiling system for these engines consists of 2 individual filters, one for each engine, placed as one unit with a large clean-oil receiver, from which the oil is pumped into the system by means of a motor-driven triplex pump running at a slow speed in order to prevent churning of the oil. This pump delivers the oil to the system at a pressure of 30 lb. per sq. in. and is equipped with an automatic by-pass which allows the oil to flow back into the clean oil compartment whenever the pressure exceeds 30 lb. For safety a duplex pump is placed in the system and connected to the compressed air line, also to the steam line; it is controlled by a Foster regulator, so that if anything happens to the motor-driven pump and the pressure in the system therefore drops below 30 lb., the duplex pump will automatically start up and thus maintain a constant oil pressure in the system.

Lubrication of the crankpin can be supplied with oil from 2 independent sources. Under ordinary conditions, oil is fed to the pin through the hollow shaft, and the supply coming from the gravity system is controlled by an extra large sight feed. In case of partial clogging of the regular supply, pressure from the oil pump can be turned directly into the pin through a large pipe, thereby flooding, cleaning, and cooling it.

Each end of each cylinder is provided with 3 igniters of the mechanical make and break type. A very simple and effective device is arranged at the end of the lay shaft for the purpose of advancing or retarding all igniters. Each cylinder has its separate circuit with coils, switch, fuses, and tell-tale lamp, all arranged on the instrument board immediately in front of the starting stand so that the operator can conveniently check the operation of the ignition system. Arrangement is made on the cylinders so that any igniter can easily be removed while the engine is in operation.

Regulating gear of the Mesta engine is exceedingly simple and efficient. Each cylinder end contains plain butterfly valves, one for gas and one for air. These valves are located immediately in front of the main inlet valve and are free to rotate without coming into contact with any rubbing surface that might cause friction. Since the vanes of these valves are very thin, there is no possibility for any impurities in the gas to collect thereon and make them "sticky."

The governor operates these valves to obtain a combination of quality and quantity regulation, and, since the butterfly valves are practically balanced, the resistance to governor control is small, so that the governor can act directly on the valve gear, without the interposition of an oil-relay.

On the blowing end of the engine is a large receiver on top of each blowing cylinder, to protect the blast line from vibration, and another a short distance away, which acts as a distributor for the 2 blast lines.

For ease of handling of the engine, 2 additional devices are of importance; namely, that for the variation of clearance space and the snorting device. Blowing engines for blast furnace service, are subjected to peculiar conditions, as the blast pressure may at times rise to 50 per cent above its normal value. If the blowing end and gas end are properly proportioned for the average conditions, the gas end is too small for the emergency condition. This trouble has been overcome by a combination of a snorting device and auxiliary clearance. In the bed plate under the blowing cylinder are 2 automatic plate valves which in ordinary operation of the engine are kept open by handwheel-operated screws.

Furthermore, some of the inlet valves at each end are connected to a piston which is controlled by compressed air. Ordinarily these valves operate just like the other inlet valves, but if a small hand lever at the outer end of the horizontal diameter of the blowing head is turned 90 deg. the abovementioned inlet valves are kept open, permitting the air to be moved in and out by the piston through these valves so that no air is delivered. This device is made use of in starting or in changing stoves. If the valves in the bed plate under the blowing cylinder are closed and the inlet valves are kept open, clearance volume is added, the effect of which is to reduce the delivery of air and also the mean effective pressure. The reduction of mean effective pressure is made use of, if the blast pressure rises beyond 22 lb. per sq. in. with poor blast furnace gas or beyond 25 lb. per sq. in. with good blast furnace gas. Depending upon the amount of pressure rise above this critical pressure, clearance volume is added either to one or both ends

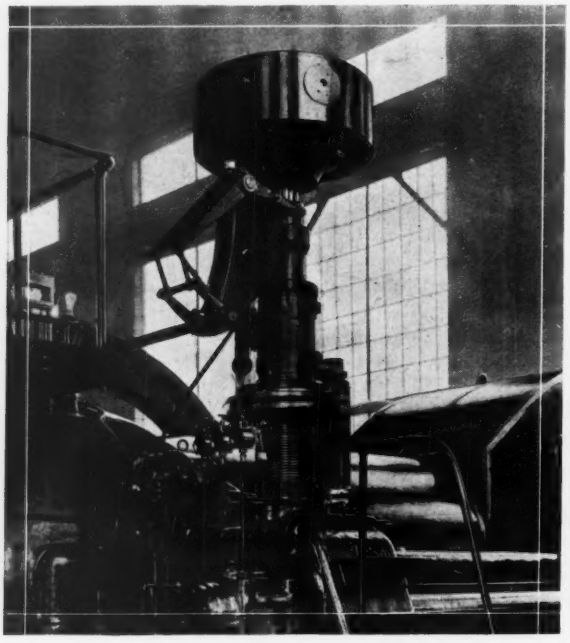

FIG. 3. GOVERNOR AND SPEED-CHANGING DEVICE

of the blowing piston. The volume of air delivered is maintained by speeding up the engine, which is designed for a maximum speed of 85 r.p.m. and has been run successfully at this speed.

Another point, of considerable value to the operator of these engines, is the ease with which the changing of air delivery from one blast line to another can be accomplished. In each blast line connection from the second receiver, mentioned above, there is placed a valve operated by compressed air. These valves are controlled from the operating stand, and by throwing a small hand lever, the changing over from one line to another can be accomplished in a few seconds, whereas in older installations of this kind, it took considerable time and manual labor to make the change.

The Pennsylvania Steel Co. has installed Venturi meters in both the gas and the blast mains so that a check can be kept on the performance of the engine.

# Peak Load in Gas Pumping

By Nat G. Pumper

OFTEN when looking over Practical Engineer, I come across the words Peak Load, and wonder how many readers know what peak load means when pushing gas, and how many men a hundred or more miles away have a cold supper and go to bed to keep warm when we fall down on the peak load.

In bad weather, when it is getting as cold as the North Pole, and all the local telephone wires are down, all one can do is to push up to the limit and trust to luck that the lines do not blow up. And, to send a man 5 mi. or more on horseback to a telegraph station or perhaps twice as far to get more wells turned on, is often our experience; also when the cold snap breaks, to have the lines freeze up solid, 10 or 20 mi. ahead, so we catch it coming and going. One lucky thing is, gas lines are not liable to freeze in extreme cold weather but, if not properly attended to, will surely close when the frost comes out of the ground.

When the mercury starts to the bottom, the gas pusher has to get busy with 200 miles of 10-in. or 12-in. main line and perhaps twice as much feed line tapped in; if his pressure ever starts down he sure has a peak load that will last him anywhere from 48 hr. to a week. Not only that, but everybody who uses gas will be cussing the gas company.

And, the isolated plant man and everybody who fires with gas will find their peak loads down under the foundation bolts some place, and when elevators stop and lamps look like the end of a burnt match, they may know the gas pusher is having troubles of his own and has found his peak load for sure.

You city engineers, just imagine pumping into a reservoir 200 or 300 mi. long with 10,000 little holes in it and 20,000 people sitting around these little holes shivering and wondering how they can sprag the meter wheels, or get those holes larger, and blaming us for pumping air into the lines when they receive their bills. And, right here I wish to state that I have the first time to see air pumped into a gas line; if any of you wish to know why, just turn over to Practical Engineer, June 1, page 539. Gas men have had miles of line blown clear out of the ditches just from the simple cause of turning in the gas with the air.

With a compressor temperature of near 300 deg., an engineer is not mixing air with his gas, if he has any sense and, if he is short on that necessary article and does mix things, some day he will quit suddenly and will not know it.

But, when the good old summer time comes and we have hustled through our necessary repairs and are carrying a light load, then we receive our reward, surrounded by green fields and woods and both hunting and fishing and good country roads, on which to burn up the gasoline that we nearly froze catching out of the drips last winter, we forget all about the cold and mud and the peak load of last winter.

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THE MACHINERY of routine kills incentive and initiative. In other words, a man can become so mechanical that he is useless.—Gaco Ramrod.

# Plunger Pumps

Power Requirements and Pump Capacities Readily Solved by Aid of Chart. By Reginald Trautschold

NO matter what the type of power house, one piece of equipment that is almost invariably present is a plunger pump. It may be required for feeding the boilers, for furnishing a water supply for fire protection or for any one of the numerous uses for which water alone provides a cheap and satisfactory medium—it may be for the testing of containers by heavy hydraulic pressure or it may be for draining a flooded area. In any event, some kind of plunger pump may be found about the establishment, and, notwithstanding its simplicity—perhaps rather on account of it, it is nearly always an important adjunct and one that is not allowed to remain idle for any great length of time.

Calculations for arriving at the capacity of such pumps and the power required for any specific duty are also easily made, for the theory of the pump is extremely simple—gallons or pounds of water handled, height elevated or pressure to be overcome or maintained and speed govern the power required, which factors are all so co-related that knowing any 2 the third is so simply ascertained as to be almost obvious. Due regard for the invariable slippage and the mechanical inefficiencies that may be conveniently grouped together as friction losses are the practical corrections that all theoretical calculations must be subjected to, but that is all. Simple as the problem is, the busy practical man finds its solution tedious and not infrequently costly time may be wasted by a careless error invited by the very simplicity of the calculation required, an error that would be much less likely to occur in more complicated calculations that by their very nature call for careful checking of results.

So intimately associated are the factors entering the questions of pump capacity and power requirements for direct-acting pumps that, for practical purposes, the solution of almost any such problem can be most expeditiously, sufficiently accurately and conveniently arrived at by the aid of a chart on which curves are plotted to depict the relationship between plunger diameter, stroke of pump, capacity, and power requirements under specific pressure. Such a chart is given in the Practical Reference Tables of this issue, the results depicted taking into account such slippage as investigations of the behavior of a large number of actual plunger pump installations indicate should be allowed and making suitable allowances for friction losses.

Though the chart actually shows only the results for simple single-acting plunger pumps, but simple calculations are required for adapting the chart to use in solving any direct-acting pump problem. For greatest accuracy, it is necessary, when calculating the capacity of double-acting pumps of any specific size, to make proper allowance for the piston, or plunger rod's reducing effect on the capacity of the crank end of the pump, but for most practical purposes this is usually unnecessary. When deemed advisable, however, the amount of reduction necessary can be easily ascertained from the chart. The following typical examples of the uses to which the chart may be put do not take into account such refinement of calculations; but, if such were desired, all that would be necessary would be a reduction in capacity by an amount equal to the capacity of a single-acting pump having a plunger of the diameter of the plunger rod of the double-acting pump and the same stroke. No correction would ordinarily have to be made in power requirement, as the slight reduction in capacity would have but little effect on the actual power consumption.

Assume having a single-acting 2-cylinder pump with a 2-in. plunger and capable of delivering 600 gal. per hr. at a pressure of 1200 lb. per sq. in.

Let it be required to find the length of stroke and the horsepower.

The delivery of 600 gal. per hr. is equivalent to 10 gal. per min. Referring to the chart mentioned above, we find at the intersection of the ordinate representing 10 gal. and that curve representing a plunger diameter of 2 in. that by extending a horizontal line to the right of the chart, the required stroke is 7½ in.

By following that ordinate representing 10 gal. per min. to the bottom of the chart, we find the horsepower required as 7.3. This value is, however, only for 1000 lb. pressure, and as the pressure specified in our problem is 1200 lb. per sq. in., it will be necessary to multiply 7.3 by 1.2, giving us 8.76 hp.

As a second problem, let it be required to find the horsepower and capacity in gallons per minute of a double-acting 2-cylinder 4 by 6-in. pump operating at 150 r.p.m. and at a pressure of 750 lb. per sq. in.

From the chart we find that a single-acting pump with a 4-in. plunger and 6-in. stroke working at 100 r.p.m. will deliver 31.25 gal. and will require 22.8 hp. to operate it.

This pump is a double-acting 2-cylinder unit, so in order to find the total number of gallons delivered, it is necessary to multiply 31.25 by 4. And further, as the chart has been constructed for a pump operating at 100 r.p.m., and as the pump in question operates at 150 r.p.m., it becomes necessary to multiply 31.25 times 4 by 1.5, giving 187.5 gal. per min.

To operate as a single-acting pump, 22.8 hp. are required, so that to operate as a 2-cylinder double-acting pump, 4 times 22.8 or 91.2 hp. will be necessary. The speed, however, as above stated, is 150 r.p.m., while the delivery pressure is but 750 lb., so that in order to correct for these values we multiply 91.2 by 1.5 times 0.75, giving us 102.6 hp.

A single-acting pump has a 2-in. plunger and 4-in. stroke and delivers 8 gal. per min. at a pressure of 500 lb. per sq. in.

Required the speed and horsepower.

From the chart we see that a 2 by 4-in. single-acting pump operating at 100 r.p.m. will deliver 5.2 gal. per min. and requires at 1000 lb. pressure 3.8 hp.

As 5.2 gal. are delivered per minute when the speed is 100 r.p.m., then 100 times 8 divided by 5.2, or 154 r.p.m., is the required speed.

The horsepower required when delivering 5.2 gal. per min. at a pressure of 1000 lb. per sq. in. and a speed of 100 r.p.m. is 3.8. The speed of the pump is, however, 154 r.p.m. and the pressure 500 lb., so that the horsepower required is equal to 3.8 times 1.54 times 0.5, or 3.

# LETTERS DIRECT FROM THE PLANT

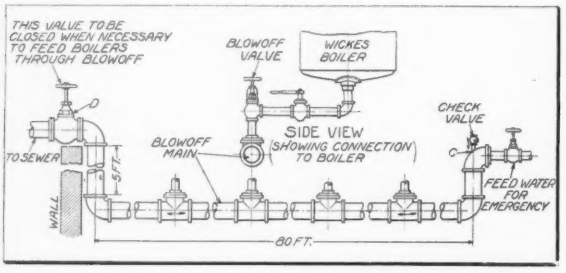
*Cash Paid For Ideas Accepted. Sketches Desirable.*
*We Make The Drawings*

## Dangerous Blowoff Piping

WHILE EMPLOYED as general boiler foreman of a large furnace, I made a successful experiment that I believe would interest and perhaps prove beneficial to some of the readers.

One battery consisted of 4 250-hp. Wickes vertical water-tube boilers. The theme of this article is the faulty and dangerous blowoff piping of these boilers, and how the dangerous element was eliminated, without changing the piping.

The blowoff main was situated in a pit at the rear of the battery several feet below the floor level. At each end of the pit, the pipe extended upward to the floor level as shown in the accompanying sketch, one way leading to the sewer, while the other end was connected to the feed water system, and with valves provided so that, in emergency, the discharge to the sewer could be




OBJECTIONABLE BLOWOFF PIPING

shut off at D and feed water from C be supplied to the boilers through the blowoff valve. This piping formed a trap in the pit, which always retained some of the water.

The result was that when the hot, boiler water was injected into the blowoff main in blowing down, perhaps the first effect was the evaporation of the water into steam at low pressure, followed quickly by condensation of this steam by coming in contact with the body of water in the piping, causing a partial vacuum to be formed and the water to be drawn to the point of vacuum, to be discharged again with accelerating velocity by accumulated pressure, producing a water hammer of dangerous proportions. Some of the elbows had given way to the shock, but fortunately no one had been injured.

On the theory expressed, I based my solution, governed also by the fact that the general arrangement could not easily be changed owing to other difficulties that would be encountered.

The remedy was effected, however, by drilling and tapping the elbow at C for a ½-in. nipple, and connecting a vertical check valve with the direction of flow inwardly to break or prevent a vacuum from being formed within the pipe. The result was successful and when the blowoff valve was opened, instead of usual violent water hammer, a loud hissing of inrush air through the check valve could be heard, which would finally stop and the check would close, as the pressure built up all was quiet, the water hammer and danger of bursting fittings and possible scalding of firemen was practically eliminated and we experienced no further trouble.

W. L. KING.

## Packing

I HAVE succeeded in making ¼ and ⅜-in. duck and rubber packing so near like the factory built article that old engineers could not tell the difference. I used old belting.

First take the piece of belting and straighten up one side of it for about 2 ft. In order to cut a strip off this edge exactly the width of the size packing required, it will be necessary to rig up some kind of guide for a knife blade. This can be done several different ways, but it must be done if packing is to be square and uniform. After it is cut, you have a strip ⅜ in. (or whatever size it is) wide and about 2 ft. long. Soak it in fairly warm water until it is wet through to make it pliable. If the packing you are making is ⅜-in., get a piece of 1¼-in. pipe about 10 in. long. Now the object is to coil the strip, while it is still wet, inside this piece of pipe. It won't want to coil up. Lay the strip down on a flat surface. With the left hand, bend the strip sharply the way it should go to coil and hit the bend lightly with a hammer. Do this along the length of the strip until it tends to form a circle. Now it will coil up in the pipe easily. Stand the pipe up on end and press the coil of packing firmly together. Stand the piece of pipe, with the packing still in it, in a warm place to dry. When the packing is dry, pull it out of the pipe and you'll have a nice coil. It may not weigh much; but when you get it well oiled and lots of graphite on it, it will weigh more, as all packing supply houses know. If you hurry, you can make 2 lb. in half an hour and any odd size you may happen to need for valve stems, etc.

Around most plants there are scraps of rawhide, or lace leather, not long enough to make laces of, that are generally thrown away. I have found these very useful as a help to the packing on rods of cold water pumps. Get the inside diameter of the stuffing-box and the diameter of the rod. Mark a circle, with a pair of dividers, on a piece of rawhide, the size of the box and inside of this a circle the size of the rod. With a real

sharp knife or a pair of shears cut out the rawhide washer. Make several of these. When you pack your cold water pump, put in a ring of regular packing, then a rawhide washer and another ring of packing, and so on. Put rawhide between each 2 rings of packing. The job will last twice as long, at least, and be tighter with less pressure.

About the largest consumer of packing around a plant is a pump, and if the bonnet over the valves has to be removed often, it can consume a tremendous amount of sheet packing. I had a big 14 by 14-in. duplex pump that maintained a pressure of about 150 lb. on a line. This pump had a habit of breaking valve stems and the only way to get inside, to drill out the end of the stem, was to lift the bonnet off the pump. This had always had a red rubber gasket. When this gasket would tear, it would have to be renewed and it was necessary to have always on hand a piece at least 2 yd. square. I took a piece of heavy copper wire and, after annealing it, brazed the ends together. Then I placed it inside the stud-bolts, in place of the rubber gasket, and put the bonnet on, and that packing trouble was cured with a permanent gasket. I have, however, tried this scheme on pumps where it didn't work on account of the stud-bolts being too few and far between. Almost all steam chest covers have enough stud-bolts to permit the use of a copper gasket. Lead fuse wire can be used instead of copper where the studs are so far apart that enough pressure can not be put on the copper to make it tight. A gasket, made out of copper wire with the ends brazed together, is used under all flat steam chest covers on locomotives.

These methods do away with having a lot of sheet packing lying around. The less packing you have in a joint the nearer it comes to being metal to metal, or a ground joint, and a metal gasket is perhaps as near perfect as some joints can be made.

F. R. Daly.

## How to Order Steam Turbines

If you are contemplating the installation of a steam turbine either to replace your present engine or to increase the capacity of your plant, it is well always to give the turbine manufacturer complete information so that he can advise you correctly. Incomplete information has often been the direct cause of improper and uneconomical installations.

For instance, if exhaust steam is available from your present engines you can make good use of that exhaust by simply attaching an exhaust steam turbine and condensing equipment. Tell the manufacturer all about your present arrangement. What is the normal horsepower developed by the present units from which exhaust steam is available? Will the load be constant after the addition or change is made? If not, what are the variations? If you have a typical load curve, send it to the manufacturer, for load curves tell big and concise stories that engineers can easily read.

Does your plant now operate condensing or non-condensing? If condensing, state the vacuum in inches. How much, if any, additional horsepower do you wish to develop? Or, do you simply wish more economical operation?

If the turbine is to drive a pump, give the number of gallons of water to be pumped per minute, give the discharge head in feet, or the pressure in pounds per square inch, and the nature of the service for which the pump is required. If for driving a blower or exhauster, state blast pressure required and quantity of air to be handled —cubic feet per minute.

If the turbine is to be used for driving a generator, state size and voltage and whether the electrical unit must be paralleled with others. Be sure to state whether current is direct or alternating. If the latter, give the number of phases and cycles.

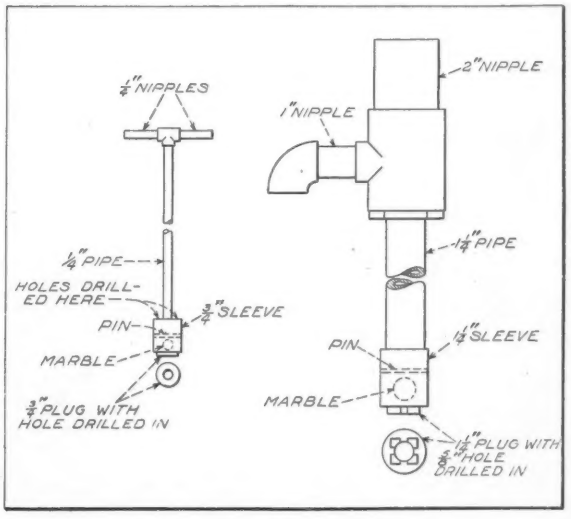
The more information you give the manufacturer, the better for both. It is almost impossible to give too many details. Sketches showing complete present and contemplated layouts are helpful.

Remember, also, that steam turbines are now usable for belt drive as well as for direct connection.

N. G. Near.

## Homemade Cylinder Oil Pump

To lift cylinder oil from a tank I made the pump shown herewith out of fittings and it has been in service more than a year, doing good work. The sketch is quite complete, so needs but little explanation. The novel feature of the pump is the use of marbles for valve discs and the pins to keep them from leaving the seat




DETAILS OF CYLINDER OIL PUMP

too far. In order that the pump may be rested upon the bottom of the tank without stopping up, after drilling the hole in the plug at the bottom I filed slots in the head, which gave ample suction area for the suction of the pump. The cylinder oil is always hot while being poured.

A. J. Irvine.

## Some Engine Troubles and Causes

A small Corliss engine was erected, without a drain in the exhaust pipe. The heater was of the closed type, and exhaust pipe of the boiler feed pump was tapped into the exhaust pipe of the engine. The pump was started first, and the exhaust, condensing, filled the pipe and cylinder with water. When the engineer started

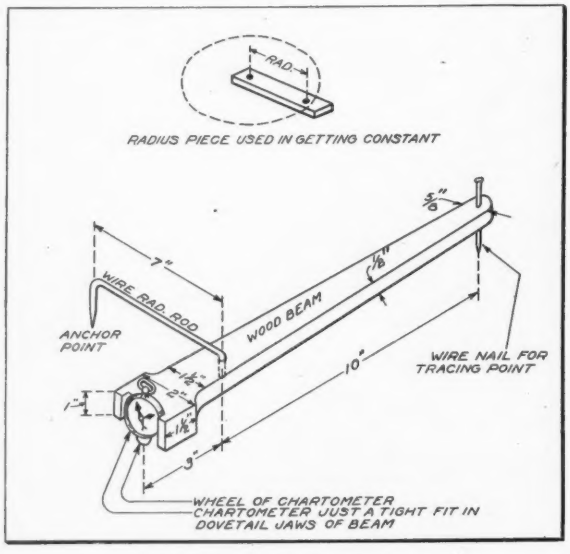
the engine, the cylinder and pipe were not sufficiently freed from water, and the engine was wrecked, frame broken, rods bent, etc.

Another engine had a knock in the cylinder, when the piston was at the head end. The engineer thought one of the sections of packing ring was broken; the piston was equipped with a sectional ring in 8 parts. The piston was removed from the cylinder and one of the sections was broken about 1½ in. from the end.

In still another case an engine developed a knock in the cylinder; sounded like a lack of compression. An indicator was applied and showed plenty; so the head was removed, and a broken follower plate was found. It was broken clear across, and was only held in place by two of the follower bolts, the other two being rendered useless by the break. Had this plate let loose, there would have been quite a repair bill. TOM JONES.

## Planimeter Made from Chartometer

REALIZING HOW often polar planimeters are needed in the design of machines; measuring indicator cards from all kinds of engines, pumps, air compressors, etc., naval architecture, boat building, military engineering and many other things and that while these instruments can commonly be found in the larger and older drafting rooms, yet as commonly made by the instrument makers are expensive it is often desirable to be able to improvise one quickly at small expense.




EASILY MADE PLANIMETER

A chartometer makes an excellent "rolling contact" and can be used to great advantage by almost every draftsman or mechanic for many purposes, such as for measuring wavy lines, the estimation of weights of castings, etc., and costs only about $2, and so is often found in draftsmen's kits. The balance of the planimeter here shown can be picked up or made almost anywhere, as the beam is simply a small piece of wood, generally pine so that it can be cut easily, and common iron telephone wire or any fairly stiff wire between 1/16 and ⅛ in. diameter answers well for the radius rod of one the size here shown, which is practically the same as one that has given the writer good service, and is so fully detailed in the cut that a further description does not seem to be necessary beyond saying that the wire radius rod should be a neat fit in the wood beam, free enough to work nicely and yet not shaky and the tracing point of course must be quite rigid in the wood beam.

To get the constant, I make a short link or radius piece of about 2 in. radius for a planimeter of the size here shown, and pin the center to a soft-wood top smooth table or drawing board and place the planimeter in position with the tracing point at the center, and the anchor point in the table-top so located that the radius rod will form about a right angle with the beam, then set the tracing point in the outer hole of the radius piece, and the chartometer to 0 and pencil-mark the location of the radius piece and pass the tracing point (all the time in the radius piece), through about 10 revolutions to the pencil mark and read the chartometer. The reading of the chartometer divided by the number of revolutions made, and by the area of a circular figure of the radius of the radius piece, will give the constant of the instrument for one square inch of surface traced; thus, with mine treated as above, we have the cardboard radius piece of 2 in. radius equals 4 in. diameter, or 12.566 sq. in., and for 10 revolutions the chartometer reads, let us say for example, 7.500 in., or 0.750 in. for one revolution and 0.750/12.56 equals 0.0596 in. per sq. in.

It is desirable always to take several test readings for the constant, and on about the area on which the instrument is to be used. To get as large a reading as possible on the chartometer either make the length of the beam in proportion to the areas to be measured, or perhaps the better way is to trace the figure several times (as 10, alluded to above). Personally, I like a long wire radius rod, never shorter in proportion to the beam than here shown, and up to twice that length, or about 14 in. for this size instrument. I have used the same chartometer on a beam 6 ft. long, overall 7½ ft. with a 6-ft. radius rod), for getting areas in square feet, that I often use on the drafting table with a beam of 6-in.-plus-2-in., with satisfactory results. One good feature about this to a man who often has to travel is that the chartometer weighs only about an ounce and can be carried in the vest pocket, and the balance rigged up and proven when and where needed. I don't think I could "keep house" now without a chartometer. F. W. SALMON.

## How to Read Belt Articles

USUALLY, IN ARTICLES by belt experts on belting calculations, belt design, transmission, etc., formulas are glibly given without the mention of a single word about the "state of the belt." One would be led to think that it makes little difference what kind of belt you use, new, old, greasy, dry, hard, stiff, pliable, soft, sticky, or anything else. The authors simply use the term "belt" as if one were as good as the other. But it is evident that this is not true.

I have found that where belts are not properly cared for, the best belt formula in the world falls flat. The belt will not pull; it will slip and run off.

I therefore hasten to state that whenever you read articles of the kind described above, you are evidently supposed to supply the omitted words yourself. For instance, instead of reading it, "A belt one inch wide, running 800 ft. per min., will transmit one horsepower," make it like this:

"A belt one inch wide, in good pulling condition, running 800 ft. per min., will transmit one horsepower."

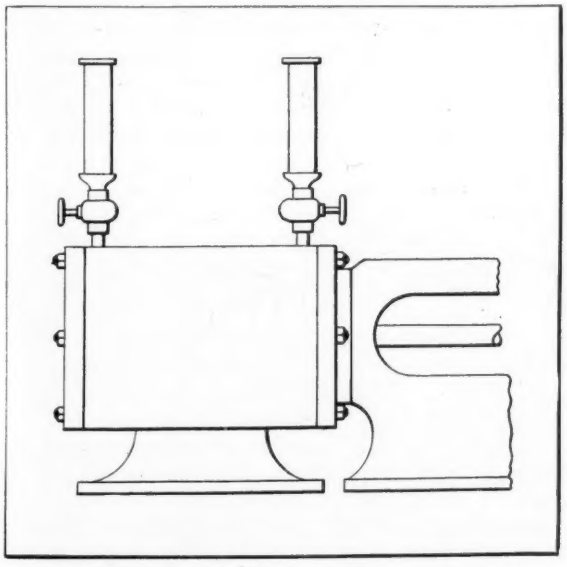
It is a fact that the latter is true, whereas the first is not always true. N. G. NEAR.

## Increasing Piston Clearance

WHILE VISITING a neighbor's plant, I saw something so decidedly new to me I consider it very novel.

The engineer had removed a portion of his indicator piping and by means of a reducing sleeve had attached a 1¼ by 12-in. nipple to each of the valves, the upper ends being capped.

As I was not able to define the usefulness of the ornamentation, the engineer cheerfully explained that the "clearance" was very small and when the load went off the compression raised the slide valve off its seat,



AIR CHAMBERS ON CYLINDER TO INCREASE CLEARANCE

thus becoming very noisy. The engine drives a dynamo that furnishes current for lighting, and a few motors.

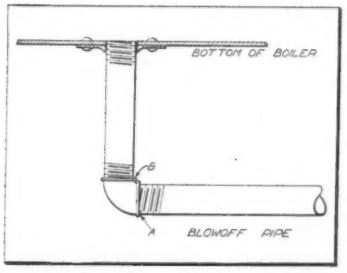
To prove his argument, he closed the indicator valves (the load being light at the time). Immediately the slide valve began to clatter on its seat; but upon opening of the valves again—giving more clearance—everything became as quiet as desired.

While this method of giving additional clearance may be old to some, I will frankly acknowledge it to be new to me. JOHN F. MCFERRAN.

EGGS SHOULD not be stored in cold storage rooms which have not been carefully whitewashed since other goods were stored in them. In fact, even when rooms are used for eggs only, a thin coat of whitewash on all exposed surfaces should be used each year.—Refrigerating World.

## Joints in Blowoff Connection

IN EXAMINING the blowoff pipe on a boiler, I found that there had been a leak at the joint A, as shown in the illustration, on the pipe leading to the outside of the boiler setting. I also found that the pipe was wasted away at this point so far that it was not safe any more, while the remainder of the pipe was in nearly as good condition as the day it was placed, which was about 6 yr. before. A new pipe was put in; but before screwing the 2 joints, A and B, together, some iron cement was placed on the threads. There was no leak at these 2 joints, nor any corrosion, when this pipe was pulled apart some




BLOWOFF PIPING THAT GAVE TROUBLE

8 yr. later. At the joint which screwed into the boiler, graphite and cylinder oil was use, so it would come out easily. Since then, when renewing the blowoff pipe on a boiler, I always cover the 2 threads which screw into the ell with iron cement and find that the pipe will last much longer due to no leak being there.

Someone may say it is hard work to pull these joints apart when renewing the pipe again. It is very seldom possible to use any of the fittings or pipe again which are pulled out of the combustion chamber of a boiler, therefore, it is better to break the fitting or cut the pipe when about to renew them. Should there be any little leak at the ell, as this ell and pipe come in contact with ashes most of the time, it would be wasted away in a short time; therefore, it is cheaper in the long run to use some material on the threads at these joints to make a tight joint. H. A. JAHNKE.

U. S. CIVIL SERVICE COMMISSION announces an examination, on July 27, 1915, for instrument maker, qualified as mechanician, to fill vacancies in this position at salaries ranging from $900 to $1020 a year, in the Bureau of Standards, Dept. of Commerce, Washington, D. C., and vacancies as they may occur in positions requiring similar qualifications.

Persons appointed as a result of this examination will be employed in the machine shop of the Bureau where high grade scientific apparatus and instruments are produced. This position has opportunities for advancement to higher grades of instrument making. Machinists and model makers are not qualified for this position. At least 4 yr. apprenticeship and 2 yr. additional work as instrument maker in a first-class scientific instrument shop, or in a high-grade physical laboratory shop, is a prerequisite for consideration for this position. Age 20 yr. or over on the date of the examination. Apply for Forms 304 and 2029, stating the title, Instrument Maker, Qualified as Mechanician (Male), to the United States Civil Service Commission, Washington, D. C.

# Questions Answered and For Answer

*Expert Help When In Trouble. If You Want Quick Answer Enclose a Stamp*

## Alternator Operation Without Excitation

IN THE May 1 issue, in the article entitled Energy Flow Through Transmission Lines, there are some statements open to question, notably the one at the top of page 443, second column, in which the author states that "an alternator may continue to carry its full load, even if its excitation is lost." I note that this is from a paper read before the A. I. E. E. and the W. S. E., so I may be wrong; but I have never known an alternator to fail to drop its load when it lost its excitation.

Kindly explain. SUBSCRIBER.

A. In order that an ordinary synchronous alternating-current generator may carry load if deprived of its direct-current field excitation, it is necessary that there be some other adequate source of alternating-current magnetizing power connected to the system. In practice, this source may be either: Another generator, preferably of considerably larger size; a synchronous motor (or synchronous condenser) of sufficiently large size; a high tension line of large electrostatic capacity.

If the magnetizing power is obtained from another generator or a synchronous motor or condenser, the direct-current excitation of such other machines must be increased sufficiently to prevent the voltage of the system falling unduly when the field current is cut off from the generator which is to run without direct-current excitation. This may be accomplished automatically by controlling the other generator or motor by a Tirrill regulator of adequate range.

When the direct-current excitation is cut off the armature current of the generator will greatly increase becoming 2, 3 or more times its normal amount. Many generators can carry such currents for a length of time sufficient to demonstrate the possibility of such operation, but cannot carry the currents continuously without burning out the armature.

By reducing the voltage on the system (by reducing the field strength of the other generators or synchronous motors which are now furnishing the magnetizing power) the armature current of the generator which has no field current may be reduced. Operation of a generator at reduced voltage, of course, necessitates an approximately corresponding reduction in the load on it, whether it obtains its excitation in the ordinary way from direct currents in the field or from alternating magnetizing currents in the armature. At such reduced voltage and output, the generator could be safely operated continuously without direct-current excitation. Any alternating generator may therefore be used to carry load when unexcited by direct current; but unless especially designed for the purpose, it should not be expected to carry full load and full voltage.

One cannot expect to get the full rated kilowatt capacity out of a generator if one makes no use of the copper on the field magnets so that for operation without field current the generator should be re-rated for a lower voltage and a smaller number of kilowatts.

For regular operation without direct-current excitation, the design of a generator should be changed to get an economical use of material. Copper should be transferred from the field magnets where it would not be used to the armature coils where it is needed to carry the magnetizing current.

It is not uncommon for a generator without direct-current excitation to build up voltage when switched onto an unloaded high-tension line. In order to charge the line, the generator must carry an appreciable load consisting of the losses of the step-up transformers, resistance loss of line for charging current, etc. Generators on large high-tension systems have in this way generated, at least at times, hundreds of kilowatts without any direct current excitation. R. A. PHILIP.

## Hoisting Engineers' Examination

THE FOLLOWING list of questions was recently asked in an examination for hoisting engineers at Terre Haute, Ind. For the benefit of our readers, we are publishing the answers also.

1. State qualifications necessary to make a successful engineer, other than those required by law.

2. When the boiler feed is perfectly free from any obstruction, and the feed pumps are at work, are the pressures in the feed pipe and boilers equal, or is the pressure in one greater than in the other? If so, what is the difference and why?

3. When the boiler feed pumps are working to supply the boilers, the water will at times feed into both boilers alike and remain at about the same level; again it will apparently all feed into one boiler only. Why?

4. What causes a horizontal return-tubular boiler to pulsate in its setting? What time is such action apt to be discernible?

5. With a pump having a steam cylinder 8 in. in diameter and a stroke of 8 in., what water pressure is obtainable with a steam pressure of 85 lb.?

6. What should be the weight of a dead-weight valve, the opening being 2⅛ in. in diameter and the blowoff pressure 60 lb. per sq. in.?

7. If a cutoff valve has a travel of 5 in., how much throw will the eccentric have?

8. The stroke of an engine is 28 in. and it makes 1500 strokes in 6 min.; what is the velocity of the piston in feet per second?

9. Give 5 reasons, any one of which may cause a flyball type of steam engine governor to fail to regulate properly the speed of the engine.

10. A horizontal tubular boiler is 11 ft., 6 in. long and 4 ft. in diameter, and has 62 tubes, each 2½ in. in diameter. Calculate the heating surface of the boiler.

ANSWERS

ABOVE ALL other qualifications, an engineer must know his business. Aside from this, in order to be successful, he must have all those other qualifications which count for success in other lines of endeavor. Briefly stated, these are honesty, love for his work, ambition, diplomacy, perseverance and loyalty.

2. With equal pressures in the feed line and boiler, no flow of water could exist. In order to produce motion either of solids or fluids, it is necessary that there be a difference in the forces acting, for, with a body acted upon by equal forces, no motion can be produced. As the water is supposed to flow from the feed lines into the boiler, the pressure in the feed line must be at least slightly greater than that existing in the boiler. This difference in pressure may be 1 lb. or it may be 10 lb., depending upon the design and performance of the pump and the design of the feed line.

Upon examination, it is found that, in the case of reciprocating boiler feed pumps, the plungers are somewhat smaller in diameter than the steam pistons. Neglecting friction of the parts, the reason for this may be explained by giving a concrete example.

Assume having a pump the cross-sectional areas of whose plungers are 20 sq. in., and the piston areas 25 sq. in. Let it be further assumed that this pump furnishes water to a boiler operating under a pressure of 100 lb. gage and at the same time supplying steam to work this pump.

The total pressure acting on the steam piston is equal to 100 times 25, or 2500 lb. This pressure is by means of the piston and plunger rod transmitted to the plunger, the cross-sectional area of which, as stated, is 20 sq. in. The unit pressure exerted by this plunger is then equal to 2500 divided by 20, or 125 lb., or the pressure of the water discharged by the pump. Therefore, we have, neglecting the friction of feed line, a difference of 125 minus 100 lb., or 25 lb., between the feed line and the boiler.

3. With boilers feeding into separate headers, this action is due to a difference of pressure, the boiler with the higher pressure taking the lesser amount of water.

With 2 boilers feeding into the same header, such action may be attributed to the fact that one boiler may possibly be working harder than the other, and even though the 2 boilers be identical in size and an equal amount of water be fed to both, the water level of the one working the harder will recede more than in the other, thereby causing it to appear as if the latter were receiving more water than the former.

4. An actual pulsation may be produced, when a comparatively small boiler is used to supply steam to a large slow-speed engine, by the engine on every stroke taking an excessive amount of steam.

On the other hand, we find boilers subject to a so-called breathing action which consists of a gradual expansion as the dampers are opened and the boiler worked hard for an oncoming load and a gradual contraction as the dampers are closed when the load dies down. This action is, however, slow and cannot be called a pulsation. A real pulsation of the boiler in its setting is dangerous and should be avoided if at all possible.

5. Without knowing the diameter of the plunger, it is impossible to calculate the available water pressure. Assume the diameter of the plunger to be 6 in. The area of a steam piston 8 in. in diameter is 50.26 sq. in. and the area of a plunger 6 in. in diameter is 28.27 sq. in. With a steam pressure of 85 lb., the total pressure on the piston is 85 times 50.26, or 4272.1 lb. This pressure transmitted to the plunger will result in a unit pressure of 4272.1 divided by the area of the plunger, or 28.27, which is equal to 151 lb.

6. With a diameter of 2⅛ in., the area of the opening is 3.54 sq. in., which, with a unit pressure of 60 lb. per sq. in., will result in a total of 60 times 3.54, or 212.4 lb. acting on the valve disk. In order to have a dead weight valve open at 60 lb. pressure, its weight will, therefore, have to be 212.4 lb.

7. Two and one-half inches.

8. Fifteen hundred strokes in 6 min. are equal to 250 strokes in 1 min., or 4.166 strokes per second. If the stroke of the engine is 28 in., the piston will travel 28 times 4.166, or 116.64 in. per sec., or 9.72 ft. per sec.

9. A. Gumming up of the parts.
   B. Oily governor belt and pulleys.
   C. Breaking of governor belt.
   D. Oil in dashpot too thick or too thin.
   E. Damaged gear teeth.

10. To find the heating surface of a horizontal tubular boiler, multiply ½ the circumference of the shell by its length; multiply the circumference of a tube by its length and by the number of tubes; to the sum of these products add ⅔ of the area of one tube sheet. From this sum, subtract the combined area of all the tube openings; divide the remainder by 144 to obtain the result in square feet.

The circumference of the shell is equal to 48 times 3.1416, or 150.79 in., which multiplied by 128 will give 19,301.12 sq. in.

Circumference of each tube is equal to 2½ times 3.1416, or 7.854 in.; 7.854 in. times 128 equals 1005.3 sq. in., or the lateral area of each tube; 1005.3 times 62 is equal to 62,328.6 sq. in., the combined lateral area of all tubes; 19,301.12 plus 62,328.6 is 81,629.72 sq. in.

The cross-sectional area of each tube is equal to 2½ squared times 0.7854, or 4.9 sq. in.; the combined area is 62 times 4.9 or 303.8 sq. in.; 81,629.72 minus 303.8, or 81,326.12 sq. in., equals the heating surface of the boiler, which is equal to 81,326.12 divided by 144, or 564.76 sq. ft. (To be continued.)

## The Modulation Heating System

PLEASE GIVE a brief description of the Modulation System of heating. E. C. W.

A. The "Modulation System" is one having a suction on the exhaust from the radiators, so that but a slight pressure is carried at the inlet,—only a few ounces. The radiators are made larger than for a pressure heating system, but somewhat smaller than for a hot water system.

The modulation feature comes in the admission valve, which is so arranged that by turning it to different positions, the radiator will be ¼, ½, ¾, or entirely full of steam. In some systems the balance of the coils are shut off entirely, in others the pressure admitted to the radiator is varied, so that the part of the coils not filled with steam will be filled with hot water.

You can get further information by writing to the American District Steam Co., North Tonawanda, N. Y., for their catalog on the subject. A. L. R.

## Fitchburg Engine Diagrams

KINDLY CRITICIZE the accompanying cards taken from a Fitchburg engine. W. C.

A. In a general way, the card at the crank end is almost ideal from this type of engine, all the lines and events being well defined and prominent.

The head end, however, shows a few things radically wrong and should be remedied in the interests of econ-

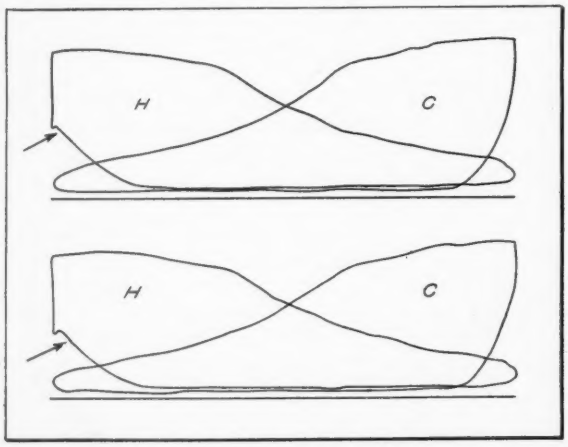



FIG. 1. CARDS SHOWING EARLY COMPRESSION AND LEAKY EXHAUST VALVE ON HEAD END

omy. Compression begins too early and the exhaust valve leaks considerably. This is shown by the fact that although compression begins earlier in the stroke by about twice what it does at the crank end, yet the terminal pressure of the compression line at that end

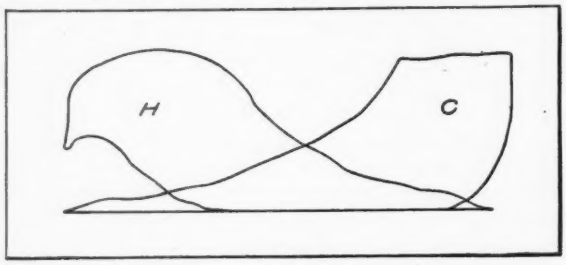



FIG. 2. HEAD-END VALVE LEAKAGE GREATER THAN COMPRESSION

is considerably less than at the head end. This shows that the exhaust valve closes earlier at that end, and in thus imprisoning a larger quantity of exhaust steam, the terminal compression pressure should be greater than at the other end. It would be possible to secure the same characteristics, if the leak occurred in the piston instead of in the exhaust valve, only that if this were the case, the characteristics would show up at both ends instead of only one.

You will note the little hook on the cards which have been indicated by the small arrows. These show the point where the leakage is greater than the compression, as the piston is almost at the end of the stroke and consequently moving slowly. If the leakage of the valve were greater, this hook would be more pronounced, as shown in Fig. 2.

Of course, this leakage will permit the continued leakage at all points of the stroke while the valve is closed, with the consequent loss in economy, and in the present card, we would say that with no further corrections than the refitting of the head end exhaust valve, you would secure the same sharp corner on the admission line that you do on the card at the crank end, and the same economy in steam. Of course, when you have repaired the valve, you should remedy the valve setting so as to secure equal compression at both ends.

G. H. WALLACE.

## Exhaust Steam Heating

I HAVE charge of a 22 by 48-in. Hamilton Corliss engine running at 90 r.p.m., noncondensing, 100 lb. boiler pressure, cutting off at about 1/5 stroke, with about 96 lb. pressure at the beginning of stroke. I am using all of the exhaust steam for heating the building. The pressure on the heating system is 1½ lb., with no steam to spare and no steam wasted.

Will I save any fuel by taking a 50-hp. load off the engine and using live steam reduced through a reducing valve to 1½ lb.? Would there be any gain in passing the live steam through a reducing valve instead of the engine? E. A. D.

A. In regard to using a reducing valve instead of your engine for bringing the steam down to the pressure required in the heating system, there would be no advantage in this; in fact, quite the contrary.

For a heating system, steam coming from the exhaust of a steam engine is better than steam which is superheated by sending through a reducing valve, as it comes to the heating system saturated or slightly moist, and will, therefore, give up its heat more readily to the heating surfaces. A. L. R.

## Whitewash Formula

KINDLY GIVE me the formula for a good whitewash such as can be applied to boiler and engine room walls and will stand considerable heat. S.

A. A formula used by the United States government in making whitewash, is as follows:

Unslaked lime, 2 pecks; common salt, 1 peck; rice flour, 3 lb.; Spanish whiting, ½ lb.; glue (clean and white), 1 lb.; water, a sufficient quantity.

Slake the lime in a vessel of about 10-gal. capacity, cover it, strain, and add salt previously dissolved in warm water. Boil the rice flour in water, soak the glue in water and dissolve in a water bath, and add both, together with the whiting in 5 gal. of hot water, to the mixture, stirring all the while together. Cover to protect from dirt, and allow to stand for a few days, when it will be ready for use. It is to be applied hot, and for that reason should be used from a kettle over a portable furnace. O. H. H.

## Commutator Lubrication

On page 503 of the May 15 issue, H. G. H. asks for information on the use of paraffin as a commutator lubricant. I have used both paraffin wax and paraffin oil with good results on commutators of large and small dynamos and motors, for the past 18 yr., and prefer the wax to any other lubricant, for it is cleaner—easier to keep the brushes clean—as it does not collect in large quantities on the brushes as oil does, and for this reason the brushes in the holders of bottom rows do not get wedged or stuck in the brush holders. Due to the fact that there is very little of the paraffin collected around the brush ends, there is no chance for dirt to stick to the brushes or the holders.

It must be remembered that paraffin wax is an insulator, and for this reason it must be used sparingly on the commutator. A slight touch of the wax stick or candle to the commutator surface and drawn across the full width of the surface is usually sufficient to last from 2 to 4 hr. After the application is made, the commutator should be rubbed immediately with a piece of heavy duck cloth, which, being a little rough, not only spreads the wax evenly on the surface, but its roughness wears the wax down to a very thin film, so the wax does not accumulate to such a thick layer as to make a perfect insulator, or even insulate enough to cause sparking.

Considerable caution must be used at first to determine the amount of wax needed to lubricate the commutator for a period of time required for the brushes to wear through the thin film, when another application is made. It is assumed that the commutator is perfectly smooth, the brushes properly set and everything pertaining thereto in perfect condition; otherwise, if the brushes sparked before the wax was used, they would spark even more after the application and perhaps cause serious burning of the segments, due to the amount of cutting and the accumulation of copper dust on the face of the brushes. The electric spark caused by the drawing of the current from one segment across the insulation to the other is generally blue at first appearance, but changes to a reddish spark as copper accumulates on the brush at the point of spark. This is due to the brush not fitting the true arc of the surface of the commutator or to the fact that some dirt of an insulating character has caught on the face of the brush, which holds it up, making a poor contact and the spark is the result.

In some cases where the insulation between the bars is a little soft or eats away rapidly, the use of paraffin wax as a lubricant will not only lubricate the surface, but the wax will accumulate in the burnt out crevices between the segment bars, filling them up full to the even surface, and prevent further burning of the edge of the segments. This is why I prefer to use it as a lubricant.

The face of the brushes resting on the commutator will collect a coating film of the wax, however, and the best way to remove it is to pass a piece of fine sandpaper between the brushes and the commutator; drawing it back and forth a few times will remove the film of wax from the face of the brush, care being used in this movement not to sandpaper the brush edges off out of a true arc of the circle of the commutator. If metal laminated brushes are used, the brush face must be scraped lightly to remove the wax, as the sand would collect between the laminations if sandpaper was used. In all cases, the brushes must be set at the proper length from the holders to have them bear properly on the commutator surface; that is, metal brushes must not be allowed to wear short and stubby. Also the tension of the spring must not be too great or it will cause wear of both the commutator and the brush; it must not be so slight as not to keep the brush in good contact, either, or chattering will result.

Paraffin oil is also a good lubricant for a commutator; as it possesses a very small quantity of the wax, it will soon produce a thin, glossy film on the surface and require a greater length of time to produce a thickness sufficient to be an insulator to any troublesome degree. This is applied to a piece of cotton cheesecloth, just lightly moistened with the oil and rubbed over the commutator. But this, like all oils, has the effect of gumming up the brushes on the bottom side and collects dirt; for this reason and the fact that it will also produce an insulating film on the face of the brush and commutator, it must be used sparingly. While other oils will lubricate and gum up the brushes, they give a little less trouble from sparking, due to the fact that their only insulating quality is in the dirt that they collect. But they require the same or more attention in keeping the brushes clean and in perfect condition. R. A. Cultra.

---

In reply to inquiry of H. G. H. in the May 15 issue, page 503, relative to using paraffin on commutators, my experience has been that paraffin is a suitable lubricant only for low-speed commutators, and especially those with hinge type brush holders. Where the commutator speed is high, the melted paraffin is thrown onto the brushes and if these are of the sliding type, they soon stick in the pockets, and if the commutator is the least out of circle, this results in excessive sparking.

In at least one instance within my personal knowledge, graphite brushes of the self-lubricating variety known as "Morganite" were used with entire success. In this case, the load factor was somewhere near the rating of the machine (0.92 or thereabout, which is high for railway work) and the commutators were hot enough to "iron clothes" when shut down. As many as 7 carbon brushes would have to be replaced in 24 hr., and they were of a standard manufacture.

After replacing them with graphite brushes, only 2 were changed in 4 months, and these were destroyed through accidents in handling. The graphite brush is not a cure for commutator trouble; but I would advise anyone who has trouble enough to cause him to try paraffin to try graphite instead in the form of a self lubricating brushes. E. E. Kaicy.

---

The oxy-acetylene welding process has been used successfully for building up flat spots on locomotive driving wheel tires and restoring them to perfect condition. Instead of removing all the drivers of locomotives and turning them down to the common diameter made necessary by the depth of the flat spots, the flats are filled in with metal welded to the tire, and in a few hours the locomotive is ready for the road. The process saves tires, machining expenses and locomotive time.—Compressed Air Magazine.

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## Selecting Valves and Fittings

Selection of the proper valves and fittings to be used in power plants is often given less consideration than the matter should have. It seems to be the prevailing custom to specify the type, size and pressure to be carried without mention of the service or conditions under which the valve is to be operated. Also, there is a tendency in many plants to let the contract for all valves to a single firm with a view of a general lower price without considering carefully the types required. For instance, one firm may make an excellent globe valve, but its gate valves may not suit the conditions so well as those of another maker.

Then again the valve to be selected depends on the service to which the valve is to be placed. For valves on the boiler feed line, pump throttle or elsewhere that are subjected to hard usage many times a day, a higher grade, and therefore more expensive, should be used. These should be so constructed that the disc may be readily renewed when worn out, and where the valve is usually only partly open, as a feed-regulating valve, the seat and disc should be of a composition that will stand considerable wear.

On the other hand, the valve on the pump steam line next to the header, and other similar places, although required to withstand the same pressure, may well be of a less expensive type, and fitted with an ordinary composition disc. Usually these valves are of the gate pattern and will be operated only at long intervals. Both valves would be required to withstand the same pressure, but the services would be different, and it would be needless expense to use the higher priced valve where the other would give as good results.

To be sure, the use of valves all made by the same company has an advantage whenever repairs or spare parts are needed,—and it is just as economical to repair valves as it is any other machinery, as all repairs can be purchased from one company, and when repairs are needed for a certain valve it is unnecessary to examine the valve, which may be neatly covered, to find out who made it. Further, some companies build several types on which the same stem, gland nut, disc and nut and other minor parts can be used interchangeably. But if all valves of a given type are from one maker, and a list is kept, this disadvantage from splitting the contract is largely overcome.

The same idea holds true as to pipe fittings. We now have standard dimension of fittings for all ordinary sizes, and if all fittings are purchased from one company, selected in view of the pressure and services required of them, it is only necessary to specify the size and pressure and send in the order with the assurance that the new fitting will be of the same dimensions as the old one, and can be put in without changing the piping.

It should be remembered that the valve or fitting has to withstand not only the actual pressure carried in the line, but also the shocks due to water hammer and vibration of the piping, strains caused by contraction and expansion, piping being out of line, abuse from ignorant or careless workmen and so on. Some of these cannot be foreseen nor anticipated, while others are not given due consideration.

Take, for instance, the feed-water line to the boilers. Where the water level is controlled by a feed-water regulator with an excess pressure governor on the feed pump; it is necessary to carry from 10 to 50 lb. excess pressure on the feed line to insure the prompt action of the regulator. In order to maintain this pressure with varying demands for water, the throttle valve on the pump is opened wide and the speed controlled by the governor. Suppose the load on the boilers drops off suddenly, and all the feed regulators close tight. The pressure will build up in the feed line and the governor will shut off steam; but if the governor disc leaks, the water pressure will go still higher, and if no relief is provided, may burst a valve or fitting. This makes it essential that the best of equipment be used in such service.

There are many uses to which the cheaper and lighter goods can be put, such as in suction lines, exhaust steam lines, low-pressure lines, etc. Also, if the pressure is fairly constant, piping in good alinement, and other conditions favorable, it is sometimes possible to use them for pressures slightly higher than that recommended by the makers. These ideal conditions, however, are seldom realized and it is better practice to select heavier goods even though they may seem unnecessarily strong, thus providing a larger margin of safety, an allowance for increase in pressure should the occasion arise at some future time, a longer life and consequently fewer renewals, which will more than offset the increased first cost.

Another point which the engineer should bear in mind in selecting valves is accessibility to the stuffing-box for repacking. There are valves on the market which have many good features in their design, but whose greatest fault lies in that the stem is so short that the packing gland nut cannot be moved back far enough to get a packing hook in to dig out the old packing, and in addition to that the hand wheel is pinned or riveted onto the stem and cannot be easily removed.

Another disadvantage found in some of the cheaper valves is that the disc and stem are solid in one piece and should the stem become bent the valve cannot be closed tight; also some have seats of such design that they cannot be readily reseated when badly worn. If it becomes necessary to replace these inferior valves after they have been in use only a short time the total cost becomes greater than if a higher grade valve had been used in the beginning.

In selecting the valves for a plant it is, therefore, necessary to consider each case separately and select those, preferably of one make, which are the best adapted to the services required consistent with a reasonably low first cost.

---

"THE MID-YEAR finds the mineral industries of the United States generally prosperous and enjoying a revival of active development." With this statement, the Director of the United States Geological Survey opens an official review of mining conditions as reported to him by the Government geologists and statisticians working on this subject. "This revival is particularly true of some of the metals for which increased demands have been noted during the past 6 months. This country has been first thrown upon its own resources for mineral products required and next, given the opportunity to supply the needs of foreign countries who have offered us their trade. Comparative freedom from foreign competition and, in some important cases, increase of foreign markets have stimulated production and a general mining advance has set in."

Summarizing the special reports at hand, Director Smith continues his review:

The 6 months' record in iron is reassuring in that hopes at the beginning of the year have been realized. Ore shipments from the Lake Superior mines have begun well, May, 1915, showing a 30 per cent increase over May, 1914. The pig iron output is also promising in its steady increase month by month, so that reasonable prophecy is for a greater total pig iron production for 1915 than for last year. Enlargement and extensions at the iron and steel plants furnish unmistakable evidence of returning business confidence.

The half year period just completed has witnessed great changes in the copper industry and in every particular the improvement has been notable. Prices, output, and wages have shown an upward trend, and prosperity is the word in the copper districts of the United States.

An unusual feature affecting coal mining has been the loss of bunker trade at the Atlantic ports, which is only partially offset by increasing exports. Reports from the West on the other hand show an increase in coal production over last year and in the East the coke output has increased considerably of late, thus showing at least the effect of the recent activity in iron and other metals.

The petroleum production for the 6 months just closed is believed to exceed that for the corresponding period last year. Unfortunately for the producers, this increase has not been in response to a demand expressed in higher prices. On the contrary the persistent flood of oil from the Oklahoma fields and from the new pools in Louisiana and Texas has prevented any permanent advance in price.

---

PUBLIC HEARING was begun on July 8 at the Bureau of Standards, Washington, D. C., on a joint appeal of the Underwriters' Laboratories, of Chicago, and the Economy Fuse & Mfg. Co., Chicago, in regard to the use of renewable cartridge fuses. The question for decision is as follows: "Has it been shown that the use of the fuses manufactured by the Economy Fuse & Mfg. Co. results in no greater fire or accident hazard than the use of other cartridge-inclosed fuses at present listed as standard by the Underwriters' Laboratories?" Dr. E. B. Rosa, acting director of the Bureau of Standards, has announced that the evidence on which the decision will be rendered will include that presented by the Underwriters' Laboratories, by the Economy Fuse & Mfg. Co., by other manufacturers of cartridge-inclosed fuses, and by insurance inspectors for state or city, all such evidence being investigated or checked by the Bureau of Standards as it may see fit. Written arguments in rebuttal of statements made at the hearing may be filed with the bureau within 15 days after the date of the hearing, that is, up to July 23.

# Power Apparatus in Shop and Market

*New Ideas In Making, Buying and Selling*

## Peerless Portable Power Plant

EVERY machine shop, foundry, manufacturing plant and garage has at some time felt the need of a portable drill and grinder capable of doing heavy work. The Peerless portable power plant shown in the accompanying illustrations combines all the advantages of a drill press and a stationary grinder and possesses, in addition, features that make it suitable for many applications where these tools could not be used. Figure 3 shows the outfit being used to remove the scale and corrosion from ammonia condensing pipes.

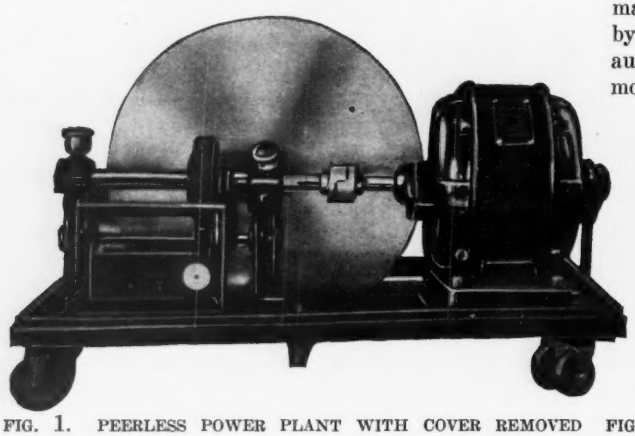


FIG. 1. PEERLESS POWER PLANT WITH COVER REMOVED

The complete power plant consists of a revolving tool bit socket mounted on the end of a flexible shaft which is driven by a Westinghouse electric motor through a variable speed friction disk device. The motor and friction drive are mounted on an iron base to which swivel casters are fitted, and the unit is enclosed in a metal case fitted with handles to facilitate carrying.

Adjustment is provided to take up wear on the driving disk and to vary the contact between the disk for various classes of service. By means of a lever, 6 speeds can be obtained at the tool and the tool can be stopped without shutting off the current from the motor. By the use of the attachments, 18 speeds, ranging from 165 to 3200 r.p.m., can be secured for grinding, drilling and polishing.

This little power plant is built in sizes ranging from ¼ to 1 hp. The largest size will accommodate drills up to 1½ in. in diameter. Flexible shafts range in length from 5 to 10 ft. All sizes are driven by Westinghouse motors and can be furnished for operation on any commercial circuit, either direct or alternating current, by the United Manufacturing Co., of Kansas City, Mo.

## Improved Industrial Type Oil Switch

THIS improved type of oil switch is used extensively in industrial establishments to control and protect induction motors up to 2500 v. and 300 amp. It can be mounted on a wall, post or other vertical supports, or by means of suitable attachments on the machine operated by the motor. The switch is made by the General Electric Co. in both nonautomatic and automatic forms; the first simply to start and stop the motor, and the second to cut off current from the motor automatically on the occurrence of an overload greater than that for which the overload trip is set.

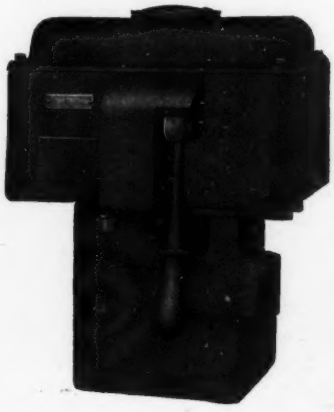
FIG. 2. PEERLESS POWER PLANT SHOWING FLEXIBLE SHAFT AND DRILLS

FIG. 3. REMOVING SCALE FROM 21-FT. AMMONIA CONDENSER PIPES

Through a recent improvement in the design of the mechanism, a low-voltage trip can be added to the automatic switch as an attachment at any time. To the nonautomatic switch, either a low-voltage trip or a series-

overload trip, or both, can be added whenever desired. Both means of tripping are mounted inside the switch cover.

Up to 550 v. (except on 110 v., 60-cycle circuits, where the trip coil only is sufficient), an auto-transformer is used in place of the resistance previously required in series with the low voltage tripping coil. This transformer has taps to which proper connections can be made for the operating voltage. For 2200-v. circuits, a new type voltage transformer replaces the transformer and series resistance used heretofore. The use of the new auto-transformer, or voltage transformer, makes the watt loss in the low-voltage device practically negligible.



GENERAL ELECTRIC OIL SWITCH WITH AUTOMATIC SERIES OVERLOAD TRIP AND LOW VOLTAGE RELEASE.

On the switch with the time limit-overload trip, the calibrating tubes and dashpots are protected from injury by a cast-iron guard which has been added to the equipment.

Switches can also be furnished with covers arranged to mount a round pattern ammeter and provide, in addition to control and protection, a means of knowing at all times the amount of current being taken by the motor. This gives a continual indication of the motor load and the opportunity to detect trouble in the motor or its circuit.

# American Balanced Piston Valve

GENERAL proportions of this piston valve, which is now used on Chandler & Taylor engines, are shown in a sectional drawing, Fig. 1. The steam enters the ports from the inside of the valve. The exhaust cavities are at the ends of the valve, and the pressure on the valve rod stuffing-box is practically nothing.

The valve cages marked K in the drawing are formed of rings slotted for the port openings. These rings, or cages, are pressed into machined portions of the cylinder casting.

The weight of the valve is carried by independent bearings at both ends. No part of the valve body is allowed to drag on the cages. The packing rings are left free to float and assume natural positions entirely unaffected by the friction due to the weight of the valve.

A section of the valve head itself is shown in Fig. 2. The description of the valve, and action of the steam in maintaining a steam tight joint is as follows:

The 2 rings marked DD are called snap rings. The inner side walls of these rings are beveled, forming a cone, and the rings are cut so they can expand and contract. Next to the snap rings are rings marked FF, called wall rings, the outer sides of which are beveled to fit the cone of the snap rings. These rings FF are called wall rings because they form the side walls for

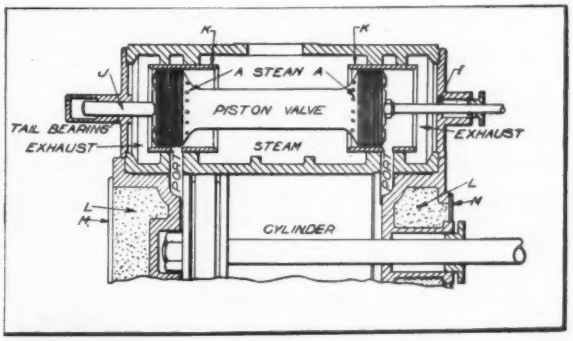



FIG. 1. SECTION THROUGH VALVE CHEST AND PART OF CYLINDER

the snap rings. These wall rings, FF, are noncut, nonexpansive steel rings. Between these wall rings, and in the center of the system, is a double-coned expansion ring lettered G, called a wedge ring. The sides of this wedge ring are beveled to fit the inner sides of the wall rings FF. This wedge ring is cut so it can contract and expand, and its effort to expand crowds the 2 wall rings FF laterally against the cone sides of the snap rings DD.

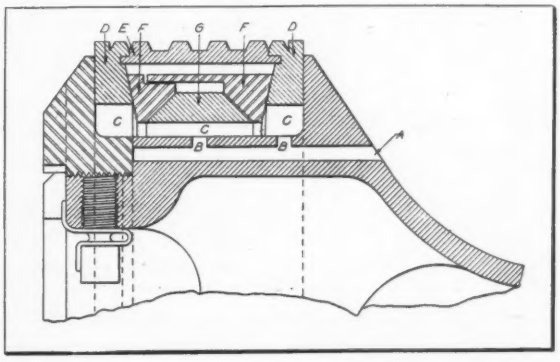



FIG. 2. SECTION THROUGH PISTON VALVE RINGS

A wide ring lettered E, cut for expansion, interlocks each snap ring DD, and completes the packing. The wide ring performs 2 important functions, first, it carries the snap ring DD across the ports, and second, it keeps the snap rings DD parallel, and of equal diameter. The wide ring E and the 2 snap rings DD, form a very flexible, yet wide packing ring.

When steam first enters the steam chest after the throttle valve is opened, it enters a series of annular ports marked A, on the inside portion of the valve heads. It flows through these ports, or holes, A, and then

through ports B, Fig. 2, into the cavity CCC. The first action of this steam is to expand the snap rings DD with their connecting ring E, out against the valve cages. As soon as these 3 outside rings DD and E touch the valve cage, the force of the steam is exerted upon the inside surface of the wedge ring G. The outward pressure of this wedge ring G against the 2 wall rings FF, is transmitted in a direction parallel to the motion of the valve, because these rings FF are solid rings, and therefore cannot expand radially.

The lateral motion of the wall rings FF locks them against the cone sides of the 2 snap rings DD, and prevents any further outward pressure of the snap rings DD, due to the pressure of steam in the chamber CCC. No steam can leak from chamber CCC out through the assemblage of rings because the pressure closes all of the joints. All of these rings are free to turn around when the steam pressure is shut off, because they are not pinned in any one position. The amount of pressure between the rings DD and E, and the valve cages, can be regulated with the greatest nicety by a variation of the angles between the rings DD and FF, and also by the variation of the angles between the rings FF and the ring G.

# News Notes

THE 29TH annual convention of the American Order of Stationary Engineers, held at Atlantic City, N. J., was voted by all present to be one of the most successful ever held, both as to the convention and as to the exhibit of the American Supply Men's Association. Much work was accomplished in the interests of the order, and the following list of officers was elected: Supreme Chief Engineer, J. William Pairent; Supreme 1st Ass't Engineer, John McKewen; Supreme Recording Engineer, John Martin; Supreme Corresponding Engineer, Edward A. Reboul; Supreme Sr. Master Mechanic, Solomon Fehnel; Supreme Jr. Master Mechanic, J. H. Monday; Supreme Inside Sentinel, Henry Messer; Supreme Outside Sentinel, John J. Morris; Supreme Chaplan, Hiram M. Trout; Supreme Trustee, Jas. K. Holland; Supreme Treasurer, William H. Tyson.

After careful consideration, it was voted that the 1916 convention shall be held at the Waldorf-Astoria in New York City, and the supply men agreed to arrange their exhibit there. New officers elected by the supply men were: President, C. A. Wilhoft, New York Belting & Packing Co.; Vice-President, Hart Hill, Lagonda Mfg. Co.; Secretary, Porter Jones, Dearborn Drug & Chemical Co.; Treasurer, John Armour, Hill Publishing Co.

AMERICAN SOCIETY OF AGRICULTURAL ENGINEERING is taking up advanced problems in the subjects pertaining to this field, and proposing for the meeting of 1915, discussions on "Heating, Lighting and Water Supply, and Sewage Disposal for Farm Dwellings," "Drainage and Irrigation for Farm Lands," "Farm Machinery," "Economics of the Farm Tractor," "The Testing of Engines, Plows and Binders," and a discussion on "Standardization of Courses for Agricultural Students." The time of the meeting has not as yet been definitely set.

AT THE annual meeting of the National Gas Engine Association, held June 23 and 24 at the Brevoort Hotel, Chicago, the following officers were elected for the ensuing year: President, C. E. Bement; Vice-President, H. D. Lauson; Secretary, H. R. Brate; Treasurer, O. M. Knoblock. Three new executive committee members elected are Y. M. Ward, R. K. Schriber and L. M. Turner.

Among the important business transacted was the adoption of a constitutional amendment providing for yearly dues of $50 for all firms or copartnership members, $10 for individual members and $5 for associate members.

THE DIAMOND POWER SPECIALTY CO., Detroit, Mich., announces that Thomas J. McMaster has been appointed district manager for its western territory.

During the past 30 yr. Mr. McMaster has acted in the capacity of sales engineer for a number of well known

concerns, and in that time he has earned an enviable reputation for trustworthiness and absolute integrity.

This appointment will without question meet with the approval of the engineering fraternity in Chicago and vicinity.

H. M. MONTGOMERY, Chairman of the Chicago Section of the American Society of Mechanical Engineers has been elected vice-president and director of the Powdered Coal Engineering & Equipment Co., of Chicago. This company is preparing elaborate plans for the construction and equipment of a large demonstration plant and research laboratory in Chicago where working demonstrations of the adaptation of powdered coal as a fuel to all forms of heat production will be carried on under engineering observation, aided by every influence that scientific research can bring to bear on the production of perfect combustion.

These tables contain data especially worked out or carefully selected that are vital to your work. You may need them at any time and should preserve them. A handy, serviceable, loose-leaf cover in which these tables fit exactly, will be sent you for 30 cents in currency or stamps.

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PRACTICAL ENGINEER

CHART 1. ECONOMIC PROPORTIONING OF VARYING LOAD TO STEAM ENGINE CAPACITY


LOAD RANGE = MAXIMUM LOAD / MINIMUM LOAD
RELATIVE STEAM CONSUMPTION - PER CENT
LOAD (POWER) RANGE - PER CENT
RELATIVE STEAM CONSUMPTION PER I.HP.
LOAD - PER CENT
R. TRAUTSCHOLD

PRACTICAL ENGINEER

RETURN TUBULAR BOILER SHOWING LOCATION AND CONNECTIONS OF USUAL FITTINGS




PRACTICAL ENGINEER

PIPE SIZES FOR CENTRAL STATION HOT WATER MAINS
Radiation at 6 lb. of water per hour

| SIZE OF LINE | 120 FEET PER MINUTE | DROP PER 100 FEET | 180 FEET PER MINUTE | DROP PER 100 FEET | 240 FEET PER MINUTE | DROP PER 100 FEET | 300 FEET PER MINUTE | DROP PER 100 FEET | 360 FEET PER MINUTE | DROP PER 100 FEET | 420 FEET PER MINUTE | DROP PER 100 FEET | 480 FEET PER MINUTE | DROP PER 100 FEET |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 4061.50 | | 6203.00 | | 8255.00 | | 10269.00 | | 12690.00 | 0.2 | 14435.5 | 0.5 | 16492 | 0.8 |
| 2 | 16401.77 | | 24501.68 | | 32701.81 | | 39884.01 | | 49065.59 | | 57257.5 | | 64441.04 | |
| 3 | 3681.51 | | 5520.105 | | 7375 1.77 | | 9190 2.66 | | 11065.375 | | 12875 6.6 | | 14720 6.9 | |
| 4 | 6500 .38 | | 98 1.5 | .79 | 13065 1.33 | | 16375 2.04 | | 19625 2.85 | | 22875 3.75 | | 26144 5.2 | |
| 5 | 10190 .31 | | 15315 .64 | | 20500 1.06 | | 25500 1.60 | | 30640 2.25 | | 35750 3.00 | | 40856 4.2 | |
| 6 | 14690 .26 | | 22065 .53 | | 29450 .89 | | 3681 5 1.30 | | 44190 1.80 | | 51500 2.00 | | 58856 3.5 | |
| 8 | 26190 .19 | | 39250 .39 | | 52315 .66 | | 65625 1.00 | | 78125 1.35 | | 91250 1.80 | | 104208 2.6 | |
| 10 | 40875 .15 | | 61375 .31 | | 81875 .53 | | 101975 .80 | | 122500 1.01 | | 143125 1.50 | | 163576 2.1 | |
| 12 | 58875 .13 | | 88125 .26 | | 117500 .49 | | 145875 .66 | | 176875 .90 | | 206250 1.20 | | 235712 1.7 | |
| 14 | 80000 .23 | | 99600 .225 | | 132600 .44 | | 165600 .57 | | 199200 .80 | | 232200 1.05 | | 264000 1.6 | |
| 15 | 76800 .18 | | 115200 .20 | | 153600 .41 | | 192600 .53 | | 231600 .74 | | 269400 .96 | | 306000 1.5 | |
| 16 | 88200 .11 | | 132600 .195 | | 176400 .35 | | 220800 .49 | | 265200 .69 | | 309000 .91 | | 348000 1.4 | |

PRACTICAL ENGINEER

HORSEPOWER AND CAPACITY OF DIRECT-ACTING PLUNGER PUMPS

J. C. HORNUNG

## NOTES ON BOILER FITTINGS AND CONNECTIONS

Feed line—Fitted with check and stop valve.

Stop valve between check valve and boiler.

Brass or steel boiler bushings through front head.

Open at end. Discharge 3/5 the distance from front head to rear head below lowest water level in direction of natural circulation.

Fusible plug—In rear head, 2 in. or more above upper row of tubes.

Water column—Connections 1-in. or larger, steam from top of shell, water from 6 in. or more below center line of boiler, water connection of brass. Lowest part of gage glass above fusible plug and lowest safe water line. Three gage cocks within visible length of gage glass.

Safety valve—Direct full opening. Discharge pipe direct full opening with open drain.

Stop valve—In each steam outlet on boiler nozzle. Provide drains where water accumulates.

Steam gage—Connected to steam space by siphon of sufficient size to fill gage tube with water. No valve allowed except cock with T or indicating valve handle in pipe near gage. Dial graduated to read 1½ times maximum allowable pressure.

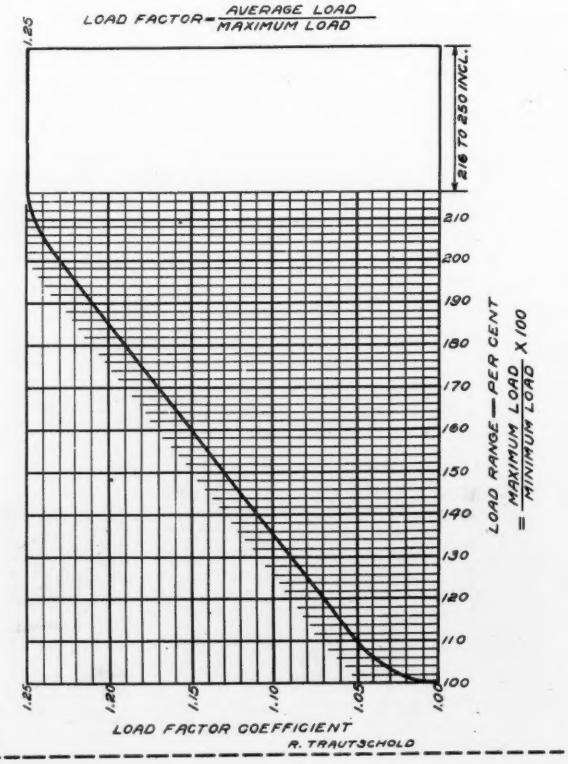
Blowoff pipe—From lowest part of boiler, insulated through heating space, pipe not over 2½ in. diameter. For pressures over 135 lb., 2 valves or a cock and a valve are required, all extra heavy fittings. Free expansion must be allowed through brick setting.

Pitch of boiler 1 in. to each 12 ft. of length.

Longitudinal joints are above the fire-line of the setting.

Brackets fit curvature of shell, not more than 2 rivets on each bracket come in same longitudinal line. From top to bottom rivets in lug not less than 12 in.

CHART II. LOAD FACTOR COEFFICIENT FOR ECONOMIC POWER RATING AT AVERAGE LOAD

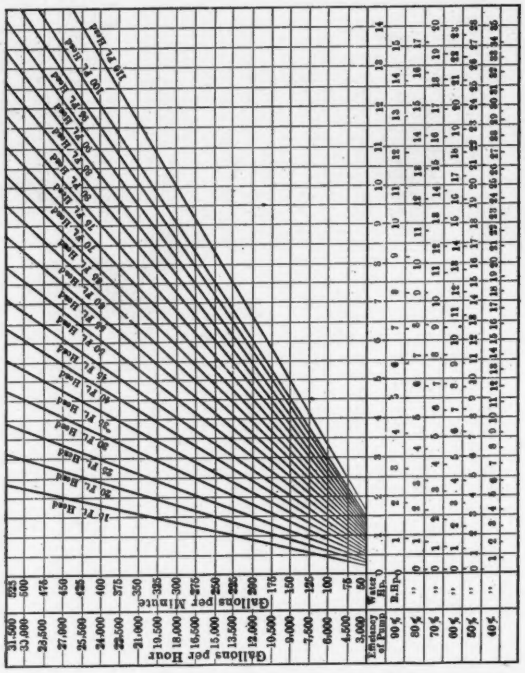

LOAD FACTOR = AVERAGE LOAD / MAXIMUM LOAD
2½ TO 250 INCL.
LOAD RANGE — PER CENT = MAXIMUM LOAD / MINIMUM LOAD X 100
LOAD FACTOR COEFFICIENT
R. TRAUTSCHOLD

PIPE SIZES FOR CENTRAL STATION STEAM MAINS
Radiation at 0.3 lb. steam per hour. Velocities in feet per second.

J. C. HORNUNG.

| SIZE OF PIPE AND VELOCITY | DROP PER 100 FEET | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ½ LB. | ¼ LB. | ½ LB. | ¾ LB. | ½ LB. | ⅝ LB. | ¾ LB. | ⅞ LB. | 1 LB. | 1¼ LB. | 1½ LB. | 1¾ LB. |
| 1" | 36 | 51 | 72 | 100 | 124 | 144 | 160 | 176 | 190 | 200 | | |
| VELOCITY | 11 | 15 | 22 | 30 | 37 | 43 | 48 | 53 | 57 | 60 | | |
| 2" | 236 | 334 | 507 | 719 | 877 | 1014 | 1135 | 1242 | 1343 | 1435 | | |
| VELOCITY | 18 | 25 | 38 | 54 | 66 | 76 | 85 | 93 | 100 | 108 | | |
| 3" | 709 | 993 | 1404 | 1993 | 2429 | 2829 | 3145 | 3440 | 3720 | 3920 | | |
| VELOCITY | 24 | 33 | 47 | 66 | 81 | 94 | 105 | 115 | 124 | 131 | | |
| 4" | 1581 | 2200 | 3113 | 4400 | 5385 | 6226 | 6973 | 7627 | 8249 | 8670 | | |
| VELOCITY | 30 | 42 | 58 | 84 | 102 | 118 | 132 | 145 | 157 | 165 | | |
| 5" | 2936 | 3701 | 5198 | 7373 | 8882 | 10384 | 11630 | 12720 | 13760 | 14600 | | |
| VELOCITY | 32 | 44 | 62 | 88 | 107 | 125 | 140 | 153 | 165 | 175 | | |
| 6" | 4146 | 5861 | 8315 | 11723 | 14465 | 16630 | 18625 | 20378 | 22035 | 23200 | | |
| VELOCITY | 35 | 49 | 69 | 97 | 120 | 139 | 155 | 170 | 184 | 193 | | |
| 8" | 8000 | 11295 | 16000 | 22560 | 27680 | 32000 | 35840 | 39200 | 42400 | 45200 | | |
| VELOCITY | 38 | 53 | 75 | 106 | 130 | 150 | 168 | 184 | 199 | 212 | | |
| 10" | 15529 | 21933 | 31000 | 43710 | 53630 | 62000 | 71940 | 75950 | 82150 | 87730 | | |
| VELOCITY | 47 | 66 | 93 | 131 | 161 | 186 | 214 | 228 | 246 | 263 | | |
| 12" | 27630 | 39190 | 49173 | 69339 | 85070 | 98346 | 110147 | 120473 | 130300 | 139160 | | |
| VELOCITY | 52 | 73 | 103 | 146 | 179 | 207 | 231 | 252 | 273 | 292 | | |
| 14" | 36450 | 51485 | 72920 | 102970 | 122350 | 145600 | 163100 | 178850 | 193450 | 205940 | | |
| VELOCITY | 56 | 79 | 110 | 158 | 187 | 223 | 249 | 274 | 295 | 315 | | |
| 16" | 50791 | 72360 | 102190 | 150290 | 177095 | 207515 | 240000 | 260000 | 280000 | 300000 | | |
| VELOCITY | 61 | 87 | 123 | 180 | 212 | 250 | 288 | 312 | 338 | 360 | | |

BRAKE HORSEPOWER TO PUMP AGAINST VARIOUS HEADS



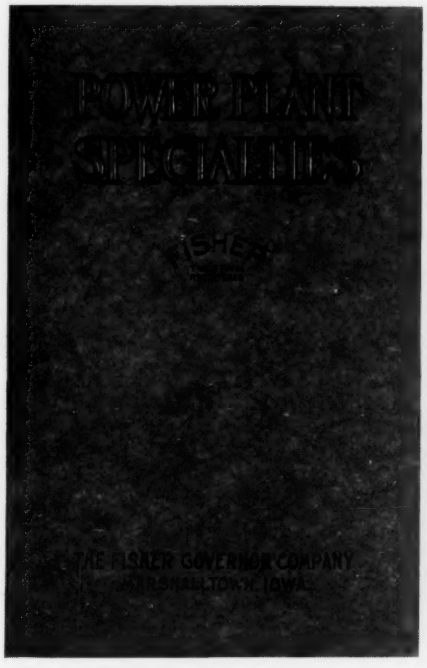

THE TERRY STEAM TURBINE CO.

# Catalog Notes

POWER PLANT SPECIALTIES, the title of a new catalog, in bulletin form, issued by the Fisher Governor Co., of Marshalltown, Ia., expresses well the contents which have been placed, in most interesting form, between the covers. The line of specialties includes all sorts of devices for the greater convenience of operation of the power plant, and the booklet as now furnished contains the following bulletins:

Number 101, on governors and regulating devices for pumps, showing the details of the apparatus, and the application for different pump service. There are various types, for regular work, for medium pressure, excess pressure, receiver operation, and for vacuum pump, in styles controlled either by spring or by diaphragm.

Bulletin 201 illustrates and describes reducing valves and pressure regulating devices, showing the details of the apparatus for medium pressures, for high pressures, and the records obtained on recording instruments by the use of these devices.




Bulletin 30 includes back pressure, automatic exhaust and relief valves, the noiseless back pressure valve being shown for noncondensing service and for condensing service, the exhaust relief for condensing service only, combination back pressure and exhaust relief for condensing and noncondensing service, and the automatic relief valve for carrying higher pressures.

Bulletin 401 includes the balanced lever, float valves and water level controlling devices. It shows various types and arrangements for controlling tank service, heater service and pump action.

Bulletin 701 lists the repair parts for Fisher specialties, and gives the price at which each part is supplied.

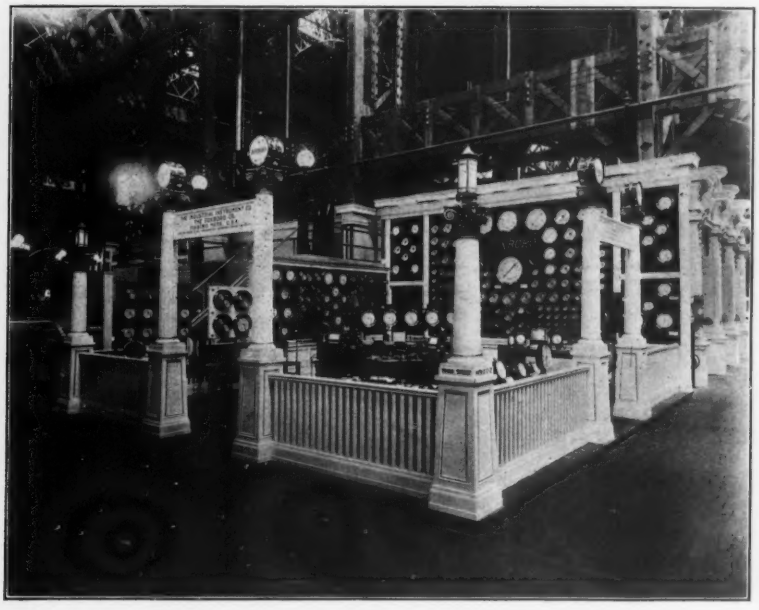
Bulletin 801 gives the dimensions for companion flanges and bolts, a table of dimensions of standard flanges and extra heavy flanges, and pricelist for flanges and for bolts.

JENKINS BROS. automatic equalizing stop and check valves, extra heavy globe or angle, are illustrated in one of the company's latest circulars.

THE WM. POWELL CO., Cincinnati, O., has lately issued a new booklet of "Powell" accessories for oil wells and refineries. A copy may be obtained on request to the company.

# Trade Notes

AT THE PANAMA-PACIFIC International Exposition, one of the interesting booths to the power plant men is that in which the Foxboro Co. is showing a complete line of indicating and recording instruments for measuring pressure, temperature, speed and time, as well as automatic temperature controllers and orifice meters. This company, which succeeded the Industrial Instrument Co., of Foxboro, Mass., and is operated under the direct supervision of B. B. and E. H. Bristol, has its booth in cream white and gold and attractively arranged. As shown in the illustration, it is enclosed by a railing surmounted by pillars, with an attractive lighting effect, and at the back is a mahogany panel, on which the different instruments are symmetrically arranged, including gages in all sizes from 2 to 24 in. diameter. On the left side of the booth is a second panel, showing thermometers, counters and similar instruments, with an orifice meter in operation, measuring the flow of gases and liquids to within one per cent accuracy. In the center of the booth, a frame holds the automatic temperature controller with recording thermometers and gages, which keep continuous record of the action of the temperature controller and the service gas pressure in the building, as well as some other quantities of which record is desired. A frequency meter, constructed on the Dr. Horn design, will show at all times on a large dial and continuous chart, the cycles per second of the electric circuits in the building.



Recording gages will indicate from the lowest possible practical vacuum up to 20,000 lb. per sq. in., and the recording thermometers have a range from 60 deg. below zero to 800 deg. F., and the pyrometers carry this range up to 3000 deg. F. A. F. Mundy, the Pacific coast manager, with C. E. Sullivan, from the Foxboro Works, and D. M. Hill, gas engineer, had charge of arranging the exhibit, and Mr. Mundy will be present at the exposition during the period that it is open.

NOTICE HAS BEEN RECEIVED that the M. K. Powers Advertising Co. has changed its name to the Powers-House Co., the offices remaining at 724 Illuminating Bldg., Cleveland, O.

In its advertising of machinery, this company endeavors to give useful information, including working speeds, operating methods, specifications, costs and economies, which will be of direct use to men who are studying the field closely, thus giving to the advertising a technical reading value which is appreciated by all users of the machinery for which this company is preparing advertising.

FRANK R. FARNHAM has joined the staff of Walter B. Snow, publicity engineer and advertising agent, Boston. Mr. Farnham was previously with the McGraw Publishing Co., in charge of copy service department for Engineering Record, Electrical World, Electric Railway Journal and Metallurgical and Chemical Engineering.

OLMSTED-FLINT CO., which on the first of the year, began operations in its new factory at Cambridge, has recently opened a New York branch at 37 Warren St., under the management of the Benjamin S. Alder Co., to care for the New York trade, and will carry stocks in all sizes and grades of belt.

BOSTON BELTING CO., 84 Linden Park St., Boston, announces the appointment of K. E. Kersten as manager of the company's Chicago branch at 172 W. Randolph St.

THE VILTER MFG. CO., Milwaukee, Wis., announces the following among recent sales: The Ice Mfg. Co., New York, N. Y., 9 coils double-pipe ammonia condenser, each coil 12 p.h. by 17 ft. 8½ in. long over bends, and 1 horizontal welded liquid receiver; The Columbia Brewing Co., Shenandoah, Pa., 6 coils atmospheric ammonia condensers, each coil 12 p.h. by 20 ft. 6 in. long over all, made up of 2-in. full weight ammonia pipe; The Burge Machine Works, Chicago, Ill., a 7-ton $CO_2$ plant; The U. S. Naval Station, Pearl Harbor, Hawaii, a 20-ton refrigerating and ice making plant; Oscar Mayer & Bros., Chicago, Ill., a 150-ton refrigerating plant; Morris & Co., Chicago, Ill., a 250-ton refrigerating plant for their plant at Oklahoma City; Emil Weiss, Greenville, Pa., a 10-ton refrigerating plant; The Mosebach Dairy, 29th and Master Sts., Philadelphia, Pa., a 25-ton refrigerating plant; J. G. Pnippenberg, Paterson, N. J., a 15-ton refrigerating plant; The Excelsior Ice Cream Co., 507 Main St., Camden, N. J., 15-ton refrigerating plant.


# PRACTICAL ENGINEER

Trade-mark, Reg. U. S. Pat. Off.

PUBLISHED ON THE FIRST AND FIFTEENTH OF EACH MONTH.

SEMI-MONTHLY

Subscription price in advance in the United States, Mexico or united possessions, $1.00 a year.

In Canada, subscription price, $1.75 a year.

Foreign Countries, subscription price, $2.50 a year.

Address all letters and make all checks and money orders payable to Technical Publishing Co., 537 So. Dearborn St., Chicago, Ill.

Any advertiser is invited to examine our paid subscription lists and Post Office mailing receipts at any time.



## ADVERTISING RATES

### Display

Full page, one year, each insertion, $60.00.

Half page, one year, each insertion, $35.00.

Quarter page, one year, each insertion, $20.00.

Eighth page, one year, each insertion, $12.00.

Front cover, $150.00 per issue.

Other specified positions, regular rate plus 10 to 50 per cent.

Stippled plates used, but no heavy, black and white plates.

### Classified Rates

Per line, 30 cents each insertion.

Advertisements in this section are inserted under regular headings.

No display type allowed, but the first three words may be set in capital letters.

About nine words make a line. Minimum space sold, two lines.

Under classification "Position Wanted," advertisements not exceeding four lines will be inserted once for subscribers free of charge.

All copy should be received at Chicago office 18 days before date of publication.

Circulation of this issue, 22,500.

**Technical Publishing Co.**

537 S. Dearborn Street

Chicago


### Position Wanted

POSITION WANTED—By young man with 10 years' practical experience from boiler room up. Hold first class Massachusetts engineer's license. Will go anywhere. Am total abstainer and can furnish A1 references. Address Practical Engineer, Box 393, Chicago, Ill. 7-15-1

POSITION WANTED—By young man, age 22, as oiler or helper in power plant. A. S. C. student. Sober. Good references. Address R. W. Peterson, 1041 S. Euclid Avenue, Oak Park, Ill. 7-15-1

POSITION WANTED—As chief engineer in small plant or assistant in large plant. At present holding a state position. Am capable of handling steam, electric and ice machines. Can do my own steam and water fitting and also all repairs called upon to do. Can give references. Willing to go anywhere. Address Practical Engineer, Box 397, Chicago, Ill. 7-15-1

POSITION WANTED—By engineer in medium sized power plant or helper in large one. Have third class Ohio license. 5 years' experience with steam engine and boilers. Some experience with electricity. Good habits. Sober. 25 years old. Good reference. Address Emmett R. Ralston, Box 43, Cheshire, Ohio. 7-1-2

POSITION WANTED—By engineer in medium sized power plant, or large coal mine. Have Illinois license; 7 years' experience with steam engines and boilers. Some experience with electricity. Good habits. References. 24. Illinois preferred. Address W. E. Rohline, Box 224, Farmington, Ill. 7-15-1

POSITION WANTED—By engineer, 8 years' experience with steam and electric. Understand gas engines and refrigeration. Temperate, reliable, married man. Member N. A. S. E. Address W. H. Snyder, 53 Brown St., Hartford, Conn. 6-15-3

POSITION WANTED—By engineer with years of experience in ice and electric light plants. Understand both a.c. and d.c. machines. Am a graduate of one of the best colleges in Middle West. A1 references. Ezra D. Dumas, Clarinda, Iowa. 7-15-1

POSITION WANTED—As assistant in power house. I. C. S. student. References. Sober. Will consider small salary if advanced as to merits. Address Fred Lamb, Box 15, Longmont, Colo. 6-15-2

## Help Wanted

ENGINEER—Good all around operating experience and pleasing personality for road work; no selling. $1500 to $1800 and expenses to start. Permanent. Applicants must be in or near Chicago. Apply The Engineering Agency, Inc., 1601-1662 Monadnock Block, Chicago. 7-15-3

WANTED—Experienced men to demonstrate and take orders for Pulle-Y-Grasp belt dressing during spare hours. Send for free sample and part. Cardinal Mfg. Co., Cleveland, O. 7-15-15

WANTED—An operating engineer for an industrial power plant consisting of both Refrigerating Systems, Air Compressors, Belt Driven A.C. Generators, etc. Alternate shifts. Steady work. $120.00 to start. First-class chance for advancement. Location, northern Wisconsin. Address Practical Engineer, Box 399, Chicago, Ill. 7-15-3

REPRESENTATIVES to cover territory more thoroughly. Boiler-room necessities; liberal commissions; old-established house. Apply by letter. H. F. Maurel, 534 West 22nd St., New York City. 7-15-6

WANTED—Resident subscription agents in the following cities: Atlanta, Ga.; Cincinnati and Columbus, Ohio; Kansas City, Mo.; Los Angeles, Calif.; Louisville, Ky.; Newark, N. J.; New Orleans, La.; Portland, Ore.; St. Louis, Mo.; San Francisco, Calif.; Washington, D. C. This is an excellent chance for a hustler, who is familiar with power plant conditions, to turn his spare time into dollars. To such a one we offer a Real Opportunity. Write Subscription Department, Practical Engineer, 537 S. Dearborn St., Chicago, Ill. tf.

FREE ENGINEERING BOOKS and power plant tools and specialties for securing new subscribers to Practical Engineer. A dandy chance for the engineer with a little spare time to get some fine premiums. Send for free descriptive circular and terms. Address Practical Engineer, Subscription Department, Chicago, Ill.

## Wanted

WANTED—Agents to handle adding Pump Counters. Big commission paid. Address Box 302, Marshall, Minn. 7-15-3

WANTED—Agents on commission to sell our Shaking Grates. We will install grates on trial or put in on test at our expense with any grate made. Address Armstrong Mfg. Company, Springfield, Ohio. tf.

WANTED—A live concern, having machine shop and foundry, to make and market a stoker designed on correct principles, on a royalty basis. Can be used on boilers, iron and steel heating furnaces, air furnaces, etc. Address Box 398, Practical Engineer, Chicago, Ill. 7-15-2

AGENCIES WANTED—The Eckel Hydrostat Co., 460 Mt. Elliott Ave., Detroit, Mich., desires steam specialties for their agents in lower Michigan. 7-1-2

WANTED—Agents handling engine and boiler-room specialties in every section for side line paying large commissions. Give experience, line carried, and territory covered. Address Practical Engineer, Box 381, Chicago, Ill. tf.

## For Sale

FANS AND MOTORS—For sale, a large number of A.C. and D.C. electric fans, new and at prices from $6.00 each upwards. All styles, including oscillating, ceiling, desk, etc. Motors alternating 1/12 to 7½ H.P., one, two, and three phase. Motors, direct current 1/40 to 30 H.P. for all voltages. Generators also. Fidelity Electric Co., Lancaster, Pa. 6-1-4

FOR SALE—(3 or 2 phase, 60 cycle, 220 volt alternators), 150 kv.a. Westinghouse late type, 900 r.p.m., $750. 125 kv.a. General Electric type ATB, 900 r.p.m., $750. 100 kv.a. Fairbanks type RF, 900 r.p.m., $550. 75 kv.a. Bullock type RF, 1200 r.p.m., $550. 175 kv.a. General Electric generator, dir. con. Atlas 4-valve engine, $1850. Duzets & Son, 50 Church St., New York, N. Y. tf.

## Patents and Patent Attorneys

PATENTS—C. L. Parker, Attorney-at-Law and Solicitor of Patents. Patents secured promptly and with special regard to the legal protection of the invention. Handbook for inventors sent upon request. 186 McGill Bldg., Washington, D. C. tf.

PATENTS THAT PROTECT AND PAY—Advice and books free. Highest references. Best results. Promptness assured. Send sketch or model for search. Watson E. Coleman, Patent Lawyer, 624 F St., Washington, D. C. tf.

PATENTS—H. W. T. Jenner, Patent Attorney and Mechanical Expert, 606 F St., Washington, D. C. Established 1883. I make a free examination and report if a patent can be had, and the exact costs. Send for full information. tf.

PATENTS—Send sketch for free search and reports. Books on patents and book of reference letters sent free. John S. Duffie & Co., 612 F St., Washington, D. C. tf.

A. P. CONNOR, consulting electrical and mechanical engineer, attorney-at-law and solicitor of patents and trade-marks. 121 Carroll St., S. E., Washington, D. C. tf.-x.

PATENTABLE IDEAS WANTED—Send for three free books. R. B. Owen, 28 Owen Bldg., Washington, D. C. tf.

## Educational and Instruction

ENGINEERS' POCKET MANUAL; 175 pages; gilt edges; bound in leather; edited by University of Tennessee; will be mailed every subscriber sending in one NEW subscription (not your own), to Practical Engineer.

## Miscellaneous

ENGINEERS, DO YOU WANT to utilize your exhaust steam for heating or drying purposes, without back pressure on your engine? If so, address Monash Engineering Co., 1413 W. Jackson Blvd., Chicago, Ill. tf.

## Inventions

INVENTIONS WANTED—Cash or royalty paid if available. Adam Fisher Mfg. Co., D175, St. Louis, Mo. tf.

# Sparks From The Advertising Pages

## WASTED ENERGY

**It pays to read the advertisements if only for the sake of keeping posted on the new things continually being developed. This fact is emphatically borne out in the following letter written to Practical Engineer by the chief engineer of a large eastern hotel. Read every word of it.**

"It is strange how much energy and thought we expend uselessly, and the amount of money we waste inventing apparatus to improve the running conditions in our plants; when, if we would keep up to the minute with the improvements and specialties the manufacturers have to offer, we would be able to save time and money by buying from them what we needed.

"Two instances of this have happened to me in the last year. We have two ——— horizontal house water heaters, heated by exhaust steam. The returns are connected to the vacuum pump that drains the house heating returns. During the afternoon and evening the use of hot water is intermittent. The temperature regulator did not close the diaphragm steam valve soon enough to prevent the vacuum pump from running away on the steam drawn through the heaters; or else we were obliged to keep the make-up water supply valve open too far, and then we wasted water. The trap installed, when the heaters were put in, would not work, so two float traps, of another make, were installed and, though that was better, it did not give us satisfaction, and we were obliged to throw them out and depend on an ordinary valve throttled down to clear the heaters of water and, at the same time hold the steam back. Of course the factor of human fallibility come in here and trouble still roosted on our shoulders.

"I then adjusted my thinking cap and in about a month I had planned a trap I felt sure would work. * * * * * * The trap is a cast iron box 18 by 10 by 5 in., with a cover bolted on. A 1¼-in. pipe connected the bottom of the trap to the top of the return line, and ⅛-in. pipe connected the vacuum gauge line to the top of the trap cover. At the end of one side is a short horizontal shaft passing through a plug with a stuffing box on the outside. On the inner end of this shaft is fastened a 12-in. arm with a 4-in. copper float at the other end of the arm. On the outside end of the shaft is a 2-in. arm connected to the valve stem of a balanced valve located on the return line. The 4-in. arm and the 12-in. arm are fastened on the same side of the shaft, so that as the float raises, the valve stem raises also.

"In operation the air is exhausted from the trap through the ⅛-in. line. The vacuum raises the water in the trap till the float is lifted, which in turn raises the valve stem of the balanced valve, admitting the condensed water through the return pipe to the pump. The opening of the balanced valve equalizes the vacuum in the trap and heater return pipe. The water in the trap lowers with the water in the heater returns, thus closing the balanced valve until the water rises in the trap again and lifts the float.

"This trap worked fine, and I naturally felt chesty in consequence; until one day I showed it to a steam specialty salesman. He smiled and asked me how much it cost me. I told him in the neighborhood of $32.00. He then took a catalog from his pocket and showed me practically the same trap, and hooked up in the same way, listed for $25.00. Of course it was Patented, but he good naturedly told me they would say nothing about it, as it had cost me more than they asked for their trap. He also thought likely I would give them a show the next time we got into trouble. And I am thinking he is about right.

"I have been studying the advertisements in PRACTICAL ENGINEER since then and have sent for catalogs and bulletins of steam specialties and interesting machinery."